THE MOVEMENTS OF THE EYELIDS.

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(Received February 11th—Read June 10th, 1879.)

THE movement of the eyelids, and the mechanism by which it is effected, have received very little systematic attention. In the following attempt to explain them it has been necessary to state some familiar facts in order to describe clearly other facts which are not commonly recognised.

The normal position of the lids, when separated, is such, in most persons, as to leave the cornea and iris unconcealed. The extent to which the globe is exposed, varies, however, according to the size of the palpebral fissure, to the prominence of the eyeball, and the position of the upper lid. The same degree of exposure is approximately maintained in the upward and downward movements of the eyeballs, except in the extreme degree of each. Thus, the lids are lowered and raised with the eyeball. The importance of this movement for vision is obvious. The upper lid can also be raised or lowered voluntarily in a considerable range of movement, and the lower lid in a much smaller extent of movement.

The two lids can be approximated, and by a greater degree of this movement they can be pressed firmly together. What is the mechanism by which these several movements are effected?

For their performance two muscles only exist: the levator palpebræ superioris, which raises the upper lid, and maintains it in elevation, and the orbicularis palpebrarum, which can lower the upper lid and raise the lower, and so bring the two together—gently when the palpebral portion contracts, forcibly when the outer circumferential part is called into action. The unstriated fibres of Müller have probably no influence on the voluntary movements of the lids.

It will be at once evident, that these two muscles, the levator and the orbicularis, do not account for all the movements of the lids, for there is no muscle which can effect the depression of the lower lid. It is probable, indeed, that these muscles have an even smaller share in the production of some of the movements than might, at first, be supposed.

Another mechanism which may be concerned in some movements of the eyelids is the movement of the eyeball. What connection exists between the two? The only direct connection is the reflection of the conjunctiva from one to the other, but the membrane at its reflection is so loose that little, if any, influence can be exerted by this connection, as experiment on the dead body readily shows. A more important relation is that of position. The surface of the eyeball presents two curves, one of the cornea, the other of the sclerotic. At the junction of the two is a depression which may be termed the sclero-corneal sulcus, and in this, in most persons, the edges of the eyelids rest when they are separated, and the expansion of the tarsal "cartilage" lies against the convexity of the sclerotic, and is kept in contact with it by the elasticity of the cartilages and by the tonic force of the orbicularis. The equatorial region of the surface of the globe is distant from its centre about one millimeter more than the bottom of the sclero-corneal sulcus. The pressure of this convexity against the tarsal "cartilage," when the globe is moved, appears to be a mechanism capable of moving the upper lid down, and

the lower lid up, with the eyeball. The pressure of the corneal prominence against the edges of the lids, may also move them with the globe, and it is probable that the lower lid is thus depressed, but the prominence of the cornea appears insufficient to affect the position of the upper lid.

The influence of the elasticity of the tarsal "cartilages," and of the tone of the orbicularis, in maintaining the eyelids in contact with the globe, is seen in the fact that the lids are to a considerable extent moulded on the eyeball, so that the point of widest separation of the lids corresponds to the middle of the cornea, and if the position of the latter is changed, as, for instance, in long standing paralysis of the external rectus, the inner part of the palpebral fissure becomes the widest part. Indeed, a similar, although slight, change in the shape of the fissure may in some individuals be observed to accompany the lateral movements of the eye in the normal condition.

The movements of the lower eyelid may be conveniently considered first, because they constitute a more simple problem, on account of the absence of any other muscle than the orbicularis. When the lids are gently closed the lower lid moves upwards in consequence of the contraction of the orbicular fibres, which, having their point of attachment near the inner canthus, may be seen to move the skin towards their attachment in raising the eyelid. This movement is slight, not more than two millimeters, no doubt because the point of attachment of the fibres is nearly on a level with the edge of the lower lid. In forcible closure of the lids, the orbicularis acts more strongly, and the extra-palpebral portion pushes up the tissues outside the lid, and so increases the degree and force of its elevation. When the eyelids are separated, the orbicularis relaxes, and the lower lid descends to its former position, in consequence apparently of its elasticity, aided perhaps by the prominence of the cornea. It is possible that its descent may be aided by the tonic force of the fibres of Müller.

The lower lid follows the movements of the eyeball upwards and downwards, but not very closely. The globe gains

upon the lid in each movement, so that in the extreme downward movement the edge of the lid covers the lower edge of the cornea, and in the extreme upward movement about two millimeters of the sclerotic are exposed below the edge of the cornea. No muscular mechanism exists which can cause the downward movement. It must, therefore, be the effect of the movement of the eyeball acting upon the lid. The action is not by means of the reflection of the conjunctiva, for this is so loose that the lid can be raised passively so as to cover the lower half of the cornea, and it cannot explain the descent of the lid, which commences as soon as the globe begins its downward movement. The depression of the lid must, therefore, be the result of the pressure of the cornea against the edge of the eyelid. This force will be uniform, or nearly so, in its action, and since the resistance to the movement—the elasticity of the attachments of the tarsal “cartilage”—will increase with the movement, the effect upon the lid progressively diminishes as the movement proceeds. Hence the globe gains upon the lid. When the eyeball returns to its normal position, the elasticity of the attachments of the lid brings it back to its place of rest with the edge in or near the sclero-corneal sulcus.

What is the cause of the upward movement of the lower lid when the eyeball is rotated upwards? The only muscular mechanism which can cause this movement is the contraction of the lower portion of the orbicularis. But if the eyelid is watched during the movement no contraction of the orbicularis can be observed. On the contrary, instead of any wrinkling or movement of the skin, such as always results from, and indicates, the contraction of these fibres, the tissues of the lower lid are extended much more than when the eye is in the mid-vertical position. Moreover, in paralysis of the orbicularis from disease of the facial nerve, the movement upwards of the lid with the globe is the same as under normal conditions. The movement must, therefore, be ascribed to the pressure of the lower convexity of the sclerotic against the tarsal “cartilage”—pressure which can be readily seen or felt if the finger is placed upon the lower lid during the

movement. The amount of elevation varies in different individuals, and is related, in part at least, to the prominence of the eyeball. If this is greater or less than normal the movement is less ; because if greater, the eyelid is already stretched over the convexity of the globe to a degree which renders the movement of the eyeball incapable of moving the lid to any considerable extent ; and if less, the sclerotic does not come forward sufficiently to press against the lid ; the relation on which the movement depends in the former case being already in operation, and in the latter not occurring at all.

Movements of the upper eyelid.—The upper lid possesses a greater range of movement, and a more complex mechanism, a special muscle being necessary, partly on account of the range and importance of its movement, and partly on account of the degree to which the lid is under the influence of gravitation, by which its descent is facilitated.

It is maintained in the normal position of elevation by the tonic action of two muscles, the levator and the orbicularis, that of the former preponderating. The influence of each of these muscles can be recognised when the other is paralysed. When the levator is paralysed, there is the familiar ptosis ; when the orbicularis is paralysed, it may be observed that the upper lid is a little higher on the paralysed than on the unparalysed side ; higher, that is, in the degree to which the levator is unopposed by the tone of the orbicularis.

The ptosis in paralysis of the levator demonstrates that the support given to the edge of the lid by the prominence of the cornea is insufficient to prevent the descent of the lid under the influence of the orbicularis and of gravitation.

When the lids are gently closed by a voluntary effort, the upper lid is lowered by a gentle contraction of the orbicularis, demonstrated by the fact that the lid descends further than it does in complete paralysis of the levator, and by the fact that in complete paralysis of the orbicularis this full descent of the lid does not occur. The closure of the lids during sleep is also effected by a gentle tonic contraction of the orbicularis. But for this movement to occur the

levator must be relaxed, and in consequence of this relaxation, when the orbicularis is paralysed and an attempt is made to close the eyes, the upper lid falls.

When the eye is "opened," the upper lid is raised by the contraction of the levator; with this is often associated a synergic contraction of the frontalis. In some persons this occurs even on gentle elevation, and in all persons in extreme elevation.

The upper lid follows the movements of the eyeball much more closely than does the lower lid, the edge being commonly maintained in juxtaposition to the edge of the cornea. The descent of the lid, on downward rotation of the globe, is not due to the contraction of the orbicularis (which causes its descent in voluntary closure of the eyes). This is proved by two facts. (1) The movement is unattended by any wrinkling of the skin such as can be observed in even slight contraction of the orbicularis. (2) The lid follows the downward movement of the globe almost, sometimes quite, as accurately if the orbicularis is paralysed as in the normal state. Gravitation no doubt assists the movement, but it is probable that the chief mechanism is the movement of the eyeball itself, the pressure of the upper convexity of the globe against the tarsal "cartilage." If the movement is closely watched, it is difficult to resist the conviction that this is the chief agency, since the upper surface of the eyeball can be seen to be rolled against the eyelid and to bulge it forwards. That this agency is effective, in addition to gravitation, is evident from the fact that when the orbicularis is paralysed, and an attempt is made to close the eyes (*i.e.* when the levator is completely relaxed and the lid is left to the influence of gravitation), it does not sink so low as it does when the eyeball is rolled downwards. The influence of the movement of the globe on the lid is increased by the circumstance that the attachment of the tarsal cartilages is considerably below the middle of the globe.

For this descent of the upper lid, in the downward movement of the eyeball, there must be a relaxation of the levator. This may appear self-evident, but it is necessary, on account

of certain pathological facts, to be presently described, to consider the proof of this relaxation.

(1) The extent of movement is so great that it is scarcely possible that it can be produced by the cause just assigned against the tonic contraction of the levator. (2) The eyeball and eyelid move uniformly; the force moving the lid acts uniformly; if the movement of the lid were opposed by so strong an elastic force as the unrelaxed tone of the levator, there would be a progressive deficiency in the movement of the lid compared with that of the globe. The uniformity in the movement, therefore, implies a relaxation of the levator in exact proportion to the movement of the globe. (3) The levator and frontalis have been seen to be associated in action, and when there is a considerable permanent tonic contraction of the frontalis (as normally in some individuals, and in partial ptosis), the eyebrow may be observed to descend, in consequence of the relaxation of the frontalis, in exact proportion as the eyeball is moved downwards and the upper lid descends. These considerations prove that there must be an accurately proportioned relaxation of the levator permitting the descent of the lid.

When the eyeball, having been rotated downwards, is again raised, the upper lid is raised with it. This is not by the influence of the globe on the lid, for, as has been already shown, the phenomena of ptosis demonstrate that the prominence of the cornea is insufficient to support, and, *a fortiori*, to move the lid. The elevation is by a contraction of the levator, corresponding in degree to the contraction of the superior rectus, just as the levator was relaxed in exact proportion to the contraction of the inferior rectus. The occurrence of this contraction of the levator, in upward movement of the eye, can be readily observed in the following manner. If the eyeball, after having been directed downwards, is quickly raised, the elevation of the lid by the levator is in excess of the movement of the globe; it is raised too high, and subsequently falls to its proper position.

This action of the levator, associated with that of the superior rectus, is entirely beyond voluntary control. In the

simulated ptosis of hysteria, for example, the upper lid is kept down by a gentle contraction of the orbicularis. But if the patient is made to look up, the levator contracts synergically with the superior rectus, and a strong contraction of the orbicularis is necessary to prevent the lid being raised.

The association of the levator and superior rectus suggests that both are relaxed in similar degree when the eyeball is moved downwards, in accordance with the law which, it is evident, must obtain in all muscular actions, that the opponents of the muscles producing the movement are relaxed in exact proportion to the degree of movement.

In gentle closure of the eyelids the levator is also relaxed, but the eyeball remains stationary,¹ the relaxation being associated with contraction of the orbicularis, the state of the recti being unaltered. In strong contraction of the orbicularis, however, the eyeball is, as is well known, rolled upwards. For this there must be contraction of the superior rectus, the inferior rectus being presumably relaxed. The levator is relaxed in forcible, just as in gentle, closure of the lids. This is proved by the circumstance that in facial paralysis the lid does not rise during the strongest attempt to close the lids.

It may be well to group these associations in a tabular form.

			Looking down.		Closing eyelids.		
				Gently.	Forcibly.		
Orbicularis	.	.	No action	...	Contraction	...	Contraction
Levator	.	.	Relaxation	...	Relaxation	...	Relaxation
Superior rectus.	.	.	Relaxation	...	Inaction	...	Contraction
Inferior rectus.	.	.	Contraction	...	Inaction	...	Relaxation.

Thus in the upward and downward movements, the state of the levator corresponds to that of the superior rectus, and is the opposite of that of the inferior rectus, and in the forcible closure of the lids, the state of the levator is the opposite of that of the superior rectus, and the same as that of the inferior rectus.

¹ This is commonly the case during sleep, natural or artificial. The statement that the eyeballs are rolled upwards during sleep, which has been current since the time of Sir Charles Bell, is, according to my own observation, true only of a small minority of cases.

From this it seems probable that the centre for the forcible closure of the lids is physiologically distinct from that for their gentle closure.

The association of the superior rectus and levator limits very much the voluntary action of the latter. The state of the superior rectus, in any position, represents nearly the maximum voluntary contraction possible of the levator. This muscle may be completely relaxed, and again contracted, but only to the degree in which the superior rectus is contracted. Hence, in each position, the lid cannot be raised much (in some persons not at all) above the edge of the cornea. If the eyes are directed downwards, for instance, the eyelid is in the same position as when the lids are closed and the eyes directed forwards. In the latter case the lids can be raised readily to the full extent, in the former case scarcely at all. This is the result of the central mechanism, for there is no local connection which prevents the movement, as experiment on the dead body readily shows.

The mechanism or path for the voluntary elevation of the lid lowered in closure of the eyelids, is, no doubt, distinct from that for the conjoint elevation of the eye and lid by the action of the levator and superior rectus. This fact, evident from the above physiological considerations, is proved also by a pathological fact presented by the patient now shown, who is in the National Hospital for the Paralysed and Epileptic, under the care of Dr. Hughlings Jackson, whom I have to thank for permission to exhibit the case. She is suffering from partial paralysis of the third nerves (probably central) causing double ptosis. When the eyes are directed straightforwards, the upper lid of each eye half covers the cornea, and she cannot by the strongest voluntary effort raise it from that position. But if she looks up, rotating upwards the eyeball, the eyelid is raised as high as normal, so as to uncover the cornea almost completely. There is thus partial paralysis of the separate action of the levator, in raising the depressed eyelid, but no paralysis of the action associated with that of the superior

rectus. This phenomenon (which I have observed in other cases) constitutes a pathological proof of the separateness of the mechanism for the different actions of the levator, which has just been inferred from physiological facts.

Other phenomena of paralysis present modifications of the movement of the eyelids, as they have been above described. One of these especially deserves mention.

If the orbicularis is paralysed, the relaxation of the levator occurs on an attempt to close the eyes, just as when the orbicularis is unparalysed. The upper lid falls, but the lids cannot be brought together. If, however, the inferior rectus is paralysed, so that the eyeball cannot be rotated downwards, an attempt at this movement is not attended by the relaxation of the levator, which, as we have seen, usually accompanies the downward movement of the globe. I show photographs of two patients presenting this condition (Plate IX). When the patient looks down, the upper lid, on the unaffected side, falls with the eyeball. On the affected side, on which the eyeball is not rotated down, the eyelid does not fall but remains in the position corresponding to that of the globe (Plate IX, fig. 2), and yet, on closing the lids, the upper one falls in the natural manner (Plate IX, fig. 3).

Thus in the absence of the downward movement of the globe, the attempt at the movement does not cause the relaxation of the levator which accompanies the actual movement. But relaxation implies inhibition of the centre which is in tonic action. The phenomena of "secondary deviation" of the eyes, would lead to the *à priori* expectation that a fruitless attempt to move the eye down would cause an increased inhibition of the levator, instead of which there occurs no inhibition at all. The practical convenience of the arrangement is more obvious than is its mechanism. The difficulty in explaining it is increased by the fact that, as just stated, the relaxation of the levator, associated with the contraction of the orbicularis, does occur when the latter is paralysed, on attempting to make it contract.

The best explanation which occurs to me is that the inhibition of the levator is not primarily the result of a central

mechanism, but is a reflex result of the effected movement. The afferent impression causing such an inhibition may originate from the contracting fibres of the inferior rectus, or from the tension on the fibres of the levator by the movement of the globe—its pressure against the tarsal cartilage being, as we have seen, the chief agent in causing the descent of the lid. It is certain that the relaxation of the levator is in exact proportion to the movement of the globe. The phenomenon is of much interest since, whatever is its mechanism is probably also the mechanism by which the relaxation of the opponents of other contracting muscles is effected.

The last point to which I would direct attention is, that the eyelids, the upper one especially, participate in the movements of the eyeball in vertical nystagmus. The mechanism for this movement is, no doubt, the same as for the other movements of the eyeball, and partly the result of the association of the levator and superior rectus, which is as marked in disease as in health.

NOTE.—Sir Charles Bell, in his work on the Nervous System, expressed the opinion that the contraction of the levator palpebræ superioris, at the same time that it raises the upper lid, presses forward the eyeball, and that this movement of the globe pushes down the lower eyelid. The assumption is, however, very difficult to prove on account of several circumstances, which Sir Charles Bell did not take into consideration. Certainly the chief part of the descent of the lower lid which occurs when the upper lid is raised is due simply to the relaxation of the orbicularis, which, even in the gentlest closure of the lids, raises the lower lid to meet the upper, and, relaxing, allows it to fall when the upper lid is raised. If the eyeballs are kept directed downwards when the eyelids are opened, the levator probably does not act at all, but the lower lid falls as much as, or more than it does during the strongest action of the levator, and the movement of the skin shows that this depression is due to the relaxation of the orbicularis. Sir Charles Bell's opinion was probably

founded on the fact that if the finger be placed against the lower eyelid while the upper lid is being raised the lower part of the globe is felt to be pushed against the finger. But it is doubtful whether this is to any extent the result of the contraction of the levator. The degree to which the eyeball can be felt to be pushed against the lower lid depends on the degree of rotation upwards of the globe with which the action of the levator is associated, and it is mainly due to the rotation of the eyeball causing the lower prominence of the sclerotic to project. Moreover, the relaxation of the orbicularis relieves the eyeball from the slight backward pressure, and consequently a slight movement forwards may result from this cause. Having regard to the action of these two causes, it seems uncertain whether the levator protrudes the globe, as Sir Charles Bell supposed.

DESCRIPTION OF PLATE IX.

(The Movement of the Eyelids. W. R. Gowers, M.D.)

Figs. 1—3.—Case 1.—Partial paralysis of left third nerve, showing that the upper eyelid remains elevated if the eyeball does not move downwards in looking down.

Fig. 1.—Position of lids on looking directly forwards.

2.—Looking down: the right eyeball is rotated downwards, the left not (paralysis of left inferior rectus); the left upper eyelid remains raised, the levator not being relaxed.

3.—Gentle closure of eyes, complete relaxation of levator on contraction of palpebral part of orbicularis.

Figs. 4—6.—Case 2.—Paralysis of left inferior rectus, showing the same fact.

Fig. 4.—Position of lids on looking directly forwards.

5.—Position of lids on looking down: the right eye is rotated downwards and the right lid falls; the left eyeball and lid remain almost in the same position as in the first figure.

6.—Gentle closure of eyelids; complete relaxation of levator and descent of lid on gentle contraction of the palpebral part of the orbicularis.