ON THE

ANATOMY AND PHYSIOLOGY

OF THE

OBLIQUE MUSCLES OF THE EYE,

IN MAN AND VERTEBRATE ANIMALS.

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NEARLY ninety years ago it was remarked by Porterfield, that "though the action of these two oblique muscles seems pretty evident, yet there is scarce any part of the human body about which anatomists have differed more than in assigning them their proper offices": and the observation is still appropriate, although the subject has since engaged the attention of various anatomists.

The question does not admit of being decided by experiments on the lower animals, chiefly because mammals are provided with an additional muscle, or series of muscles, for retracting or suspending the eye, which are beyond the reach of trustworthy experiment, and to which motions of the eyeball might be owing after the straight muscles had been divided. Accordingly, the opinions of most authors on this matter are founded upon a consideration of the manner in which it appeared to them that these muscles, from their direction and attachments, would influence the ball of the eye, so as to change the direction of its axis; and very different conclusions have been arrived at by the most eminent of anatomists and physiologists.

A necessary preliminary to such an inquiry, is a correct understanding as to the manner in which the eyeball actually moves. It appears to me that all the movements of the eyeball are purely rotatory in their nature, as if it moved within a close-fitting socket, or, as it were, on an universal pivot at its centre. The axis on which

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the rotatory motions occur will always be at right angles to the moving power—transverse when the upper and lower recti act, vertical during the action of the lateral recti, and intermediate in the diagonal movements, which are performed by the conjoint action of two neighbouring recti muscles. Again, in the motion of circumduction, as in turning the eyes round a room, which is performed by the alternate action of the four straight muscles, the centre, as it were, still remains unmoved, one end of the axis being depressed as the other is raised, and so on. In accordance with this we find the straight muscles sweeping over the globe of the eye, to become inserted considerably anterior to its middle, so as to fit them for producing these various motions; by all of which, it will be observed, the direction of its axis is changed. But it is held by some, that, independent of any change in the direction of its axis, the eye, under certain circumstances, undergoes a movement quite different in its nature—that of rotation on its antero-posterior axis, or what is usually called the axis of the eye,—and that it is the function of the oblique muscles to produce this movement: which I shall call *lateral rotation.*

It appeared to me that light might be thrown on this disputed subject by the evidence which comparative anatomy would no doubt afford; for, although the existence of corresponding muscles has been noticed in passing, by various writers on comparative anatomy, the arrangement of them with reference to their action on the eye does not appear to have been inquired into; and, having made careful dissections of these parts, in a great variety of instances, I am enabled to furnish, from my notes, the following summary of the arrangement of the oblique muscles in the different classes of vertebrate animals,—avoiding notice of the comparative anatomy of the other muscles of the eye, as in no way affecting the present inquiry.

In Mammalia, the *superior oblique* has the same general arrangement as in man. The differences may be stated thus:—1, That it is usually fleshy for some distance beyond the pulley, and therefore longer, at the same time that it is relatively larger. 2, It is usually not, as in man, directed backwards to the axis of the eye, but meets it nearly at right angles; and its course from the pulley to the eye is more horizontal than in man: and 3, That its point of insertion is not so far towards the outer and back part of the eye as in man, but is usually only a little external to the vertical axis, and not more behind than in front of it. The insertion varies slightly in different animals, but in the greater number the insertion of the tendon is chiefly concealed by the upper rectus, the posterior border only appearing beyond it; whereas, in man, the tendon passes some way beyond, and also behind the vertical axis of the eye. The *inferior oblique*, also arising as in man, is not, as in him, directed backwards to the axis, but either forwards or at right angles to it. But the most striking difference is in the insertion. This in man is towards the posterior part of the eye, but in quadrupeds it is much farther

forwards, as well as lower down. Usually it is attached between the lower and outer recti—its posterior border often reaching a little beneath the latter—and to the anterior third of the sclerotica, in some coming quite close to the margin of the cornea.

In BIRDS, REPTILES, and FISHES, the *superior* oblique arises from the fore part of the orbit, and is precisely the counterpart of the *inferior*, which is disposed much as in the mammalia; and there is so little difference in their arrangement in these different classes of vertebrate animals that they scarcely require separate description in each. The two muscles arise together from the fore part of the inner, or anterior, wall of the orbit. Passing outwards, they soon separate, the superior to be inserted near to the tendon of the upper rectus, the inferior to a corresponding point below; their direction to the axis of the eye being at right angles, or more usually somewhat forwards. In *birds*, the superior oblique is much the largest muscle of the eye, being two or three times the size of the inferior, which is not much larger than one of the recti. It is broadest at the insertion, which is partly beneath the tendon of the superior rectus, reaching near, and sometimes up to, the outer border of that tendon; but the greater part is attached, on its inner side, at the upper part of the space between it and the internal rectus. The *inferior* oblique is inserted partly in front of the tendon of the lower rectus, and partly to its inner side, and is nearer to the cornea, or osseous zone, than the superior. The space between the eye and the two oblique muscles is occupied by a large branch of the fifth nerve and part of the Harderian gland, which supports the eye in its lower and inner aspects. In *reptiles* they seem not to pass so far outwards. In the frog more particularly, the superior is attached to the inside of the tendon of the upper rectus, and is not larger than the inferior; and the two muscles meet the axis of the eye at right angles. But in *fishes* they pass further outwards—the superior in front of and over the tendon of the upper rectus, to be inserted partly in front of it, and partly to its outer side; and the inferior has a corresponding position and attachment below. They are directed somewhat forwards to the axis of the eye.

In inferring the action of these muscles from their anatomy, it is essential to notice their direction with reference to the axis, and also whether they are attached before, behind, or at the middle of the eye. In man they are attached behind the middle, especially the inferior, and their direction is backwards to the axis. In most mammals the superior oblique is not nearer to the front than the posterior part of the eye, but the inferior is rather nearer to the former, and both the muscles are of great breadth. In man the axes of the eyes are directed almost straightforward, but as we descend the scale of vertebrate animals, they become more and more turned outwards. Among mammals the direction of the axes varies considerably. When they look much forwards—as, for instance, in the cat—the line of action of the oblique muscles is directed backwards, as in

man. When the axes are turned quite outwards—as in the rabbit and hare, in which the axes of both eyes cannot possibly be directed to the same object—the oblique muscles are then directed forwards to the axis; but in most quadrupeds,—in which the eyes look forwards and outwards, so that if both eyes are used on one object the visual axis cannot correspond to the axis of the eye,—they may be said to meet the axis at a right angle, as well as to embrace the middle of the eye. In birds, most reptiles, and in fishes, the eyes are placed so that the rays from one object cannot enter both pupils, and from this outward direction of the eyes the oblique muscles are directed somewhat forwards to the axis, although often nearly at right angles. Also they are usually, in these classes, attached rather in front of the middle of the eye, although from their great breadth they embrace a considerable part of it. Whilst I have described their direction in these classes, and in some mammals, as being rather forwards to the axes of the eyes, their actual direction in the orbits is backwards when the opposite sides are considered together; but in most mammals their course is nearly horizontal, and in some even a little forwards in the orbits, at the same time that they are nearly at right angles to the axes of the eyes; so that one of their uses cannot be to advance the eyes, as has been supposed.

As to their comparative development. In the two lower classes of the vertebrata, the two oblique muscles are of nearly equal size, the inferior is, at least, not smaller than the superior, and they are larger than the straight muscles. In birds, while the inferior continues somewhat larger than one of the recti, the superior has undergone a great increase, being, as already stated, two or three times larger or broader than the inferior. Lastly, in mammals, the superior oblique undergoes a further development, at least in length, by its reflection over a pulley, after arising backwards from near the apex of the orbit. Notwithstanding this, it does not seem to be the more powerful of the two oblique muscles, as the inferior appears to contain more muscular substance, from its being broader and fleshy nearer to its insertion, and is besides situated so as to be capable of effecting a more extensive motion, at least of a lateral rotatory kind, than the superior. This is more the case in man than most quadrupeds, in which the superior has the advantage of being fleshy beyond the pulley, which is then large and loose, so as not to confine the muscular fibres. The oblique muscles appear, also, to be in most quadrupeds more developed than in man, when compared with the straight muscles and with the size of the eye; but, on the other hand, in man the oblique muscles pass more round the eye, from which they would appear to gain an advantage, as regards turning the eye on its axis. Farther, the lesser development of the oblique muscles, compared with the recti, in mammals, than in the inferior classes, may perhaps be more correctly regarded as due to the increase of the recti in the former, in accordance with the greater frequency and extent of the

movements of the eye, more especially in man, and also in other mammalia.

These observations may be regarded as affording just grounds from which to draw conclusions as to the use of the oblique muscles. Whatever minor differences they may present, they are evidently the same muscles, and provided for the same purpose in all vertebrate animals, and no hypothesis can be entertained if it is incompatible with, or not supported by, comparative anatomy.

It has been a common opinion that the oblique muscles advance the eye, and act as antagonists to the recti, so as also to steady the eye during the action of the latter. To this it has been objected, that they exist in animals where the eye cannot be retracted, and that they are not proportionally increased where a special retractor or suspensory muscle exists. To this it may be added, that they exist in man in whom retraction of the eye does not naturally occur as a voluntary movement, as is easily ascertained by experiment, although, by the conjoint action of all the straight muscles, or of two opposite ones, such a movement would be produced; and in most mammals the course of the oblique muscles in the orbit is not sufficiently backwards to permit of their advancing the eye, which is probably accomplished by the resilience of the soft parts, against which it has been drawn by the action of the suspensory muscle.

It has also been held, that one use, at least, of the oblique muscles is to compress the eye laterally, so as—by rendering the cornea more convex, and by increasing the distance of the lens from the retina—to fit the eye for the vision of near objects. But, as this could be only a secondary use of these muscles, it may be observed, that, although both eyes usually converge equally when near objects are viewed, the effect would be liable to be produced unequally, and at times when it was not required. Besides, this hypothesis is now rendered unnecessary, the question, as to how otherwise the optical change is effected, having been satisfactorily settled by the recent microscopical observations of Mr Bowman, which confirm the conjecture long since made by Porterfield, that the ciliary circle or ligament is muscular or contractile in its nature, and can thus readily advance the lens, by acting on it through the ciliary processes and its suspensory ligament.

Again, it has been supposed that the oblique muscles might act so as to turn the cornea inwards. It is not easy to see how, singly or combined, they could perform a rotatory movement of this nature, as this would require them to be attached considerably before the centre of the eye, and the internal rectus does not appear to stand more in need of assistance than any of its fellows. This opinion, however, has been brought by some to explain why the power of turning the eye inwards may remain after the internal rectus is divided, or believed to be so, in the operation for convergent strabismus; whilst others explain the same circumstance by supposing that the

inner fibres of the upper and lower recti can act so as to invert the eye. Even those who believe that the power of turning the eye inwards may not be destroyed by division of the internal rectus, will admit that such is at least not usually the case, from which it may be inferred, that there is no muscle, or combination of muscles, by which inversion of the eye can be naturally performed after the internal rectus is divided; otherwise there is no reason why the power of inversion should not always remain. This I have never yet observed in any case where I felt satisfied that the muscle was wholly divided. When any power of inversion remains, I regard it as indicating the necessity of searching for some part of the muscle which has escaped division, and I have not yet found it necessary to divide any other muscle, in whole or in part, in addition to the internal rectus, for the complete removal of convergent strabismus. The power of inversion returns, though to a lesser, but still sufficient, extent, after the muscle or tendon has re-adhered to the sclerotica.

The view most commonly entertained is, that each of the oblique muscles performs, or assists in performing, one or more of the diagonal movements of the eye, whereby the direction of its axis is changed. Acting singly, the superior has been variously held to turn the cornea downwards and inwards, and, again, downwards and outwards; and the inferior upwards and outwards, and, again, upwards and inwards. The names of the most eminent of anatomists and physiologists are attached to these opposite views, although the more strongly supported view is, that each performs the latter of the two movements above assigned to it. Assuming the latter view to be correct,—namely, that by the superior the cornea is directed downwards and outwards, and upwards and inwards by the inferior,—Valentin has founded on it an ingenious theory, chiefly intended to give an explanation of the singular arrangement of the motor nerves of the orbit. But, irrespective of a variety of objections of another nature, which might be taken to this theory, it is enough to remark here, that it essentially rests on the ground that the oblique muscles are capable of performing the movements above attributed to them. This, indeed, they might possibly be believed to do in man, but it is at once evident, from a consideration of their comparative anatomy, that they could not perform these movements in animals; in which, notwithstanding, there is the same peculiar arrangement of the motor nerves. Indeed, there is no good reason to believe that any of the muscles of the eye, or their nerves, are more involuntary than the others, all being alike under that influence which maintains the harmony of the ocular movements; which are alike consensual whether the muscles employed be corresponding, or non-corresponding ones, on the opposite sides.

The view that the oblique muscles are provided for the purpose of turning the eye on its antero-posterior axis, is not a new one. It was advocated, in 1759, by Porterfield, and seems, from the remarks in his treatise on the eye, to have been the subject of dis-

cussion previous to that time, some having denied the existence of such a movement, as they could neither perceive its utility nor observe its occurrence. It was brought forward in 1786 by John Hunter, in a short paper on the use of the oblique muscles, among his observations on some parts of the animal œconomy, in which he has endeavoured to explain the circumstances under which such a movement is necessary; and the same view is attributed to Dr Jacob, of Dublin, in the last edition of Quain's Anatomy.[1] The view of Hunter is well advocated by Dr G. Johnson, of King's College, London, in the article "Orbit" in the Cyclopædia of Anatomy and Physiology; and he adduces in support of it the result of experiments performed by him on a newly killed dog, from which it appeared that the contraction of the oblique muscles caused the eye to roll on its axis in opposite directions, without causing, in the slightest degree, any of the movements by which the direction of the axis is changed.

The physiological uses of such a movement are not at first sight very apparent. In those lateral motions of the head, which take place between the atlas and axis, the eyes, in being kept fixed on an object previously viewed, are moved laterally by the recti muscles; but, as Hunter explains, when it is moved laterally, as from shoulder to shoulder, rotatory motion of the eyes, on their antero-posterior axes, is also required, to prevent the picture from changing its place circularly on the retina. Thus, when the head is bent down towards the right shoulder, the right superior and the left inferior oblique will be in action. It is evident, under such circumstances, when the head is twisted round on an axis more or less corresponding to that of the eye or eyes—that the latter must be rotated more or less directly on their axes, and in a contrary direction, otherwise the picture of the object would change its place circularly on the retina. This motion will be more or less combined with those performed by the straight muscles, according as the axis of motion of the head corresponds more or less to that of the eyes; and it may be that the oblique muscles, from their not exactly embracing the middle of the eye transversely, are intended also, and at the same time, to turn the axis of the eye, so as to change, to a certain extent, its direction. It would appear, therefore,—as it is essential to the

[1] Since the above appeared in the Journal, I have been favoured with a copy of Dr Jacob's very instructive paper "On Paralytic, Neuralgic, and other Nervous Diseases of the Eye," from the *Dublin Medical Press*, for January 6, 1849, on which I had been unable to lay my hands in Edinburgh. In support of his opinion that the function of the oblique muscles is to turn the eye on its antero-posterior axis, Dr Jacob relates cases in which the action of the superior oblique was rendered apparent, from the muscles supplied by the third and sixth nerves being paralysed. It became evident when the patients were directed to look downwards, the motion being a delicate rotatory one, the eye being distinctly twisted on its axis. Dr Jacob also takes the same view as to the purely rotatory nature of the various movements of the eye.

correct viewing of an object when the head is being moved, that the picture fall in all respects on the same part of the retina,—that a more or less direct movement of rotation on the antero-posterior axis is very necessary; and it may be added, that the nature of this movement—as it causes little or no change in the direction of the eye—together with the circumstances under which it takes place, are such as not to render its occurrence evident to an observer. The circumstances under which this movement would be required in those animals in which the eyes are placed in the side of the head, and look outwards, are different; as, in the simple movement of raising or depressing the head, the latter moves more on an axis corresponding to that of the eyes, so as to render a more direct lateral rotatory motion necessary, in order to prevent the image from changing its place circularly on the retina. In these animals, it is doubtful if the eyes, which cannot be directed together to the same object, are moved simultaneously; but if so, the corresponding oblique muscles will be employed at the same time on opposite sides, whereas, in the circumstances explained by Hunter, the superior oblique of the one side would be in action along with the inferior of the other.

These, however, are so far only theoretical considerations, and do not affect the conclusion to which comparative anatomy points, that the oblique muscles—whatever minor differences may obtain as to their arrangement in different vertebrate animals—are, in all, not only capable of performing this movement in opposite directions, but are evidently intended for doing so.

It would thus appear, that, while comparative anatomy is irreconcilable with all the other theories above alluded to, it affords strong confirmation of the view that the oblique muscles are specially provided for turning the eye, more or less directly, on its antero-posterior axis.

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