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Accommodation: The role of the external muscles of the eye A consideration of refractive errors in relation to extraocular malfunction

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ABSTRACT

Speculation as to optical malfunction has led to dissatisfaction with the theory that the lens is the sole agent in accommodation and to the suggestion that other parts of the eye are also conjointly involved.

Around half-a-century ago, Robert Brooks Simpkins suggested that the mechanical features of the human eye were precisely such as to allow for a *lengthening* of the globe when the eye accommodated. Simpkins was not an optical man but his theory is both imaginative and comprehensive and deserves consideration.

It is submitted here that accommodation is in fact a *twofold* process, and that although involving the lens, is achieved primarily by means of a give – and – take interplay between adducting and abducting external muscles, whereby an elongation of the eyeball is brought about by a stretching of the delicate elastic fibres immediately behind the cornea.

The three muscles responsible for convergence (superior, internal and inferior recti) *all pull from in front backwards*, while of the three abductors (external rectus and the two obliques) the obliques *pull from behind forwards*, allowing for an easy elongation as the eye turns inwards and a return to its original length as the abducting muscles regain their former tension, returning the eye to distance vision.

In refractive errors, the altered length of the eyeball disturbs the harmonious give – and – take relationship between adductors and abductors. Such stresses are likely to be perpetuated and the error exacerbated. Speculation is not directed towards a search for a possible cause of the muscular imbalance, since none is suspected.

Muscles not used rapidly lose tone, as evidenced after removal of a limb from plaster. Early attention to the need for restorative exercise is essential and results usually impressive. If flexibility of the external muscles of the eyes is essential for continuing good sight, presbyopia can be avoided and with it the supposed necessity of glasses in middle life.

Early attention to the need for muscle flexibility and for frequent change of focus, it is believed, leads to ocular wellbeing and obviates the reliance on glasses. It is a consideration yet to be widely entertained.

The alarming increase in myopia has led to considerable investigation in recent years as to increase in the length of the eyeball. Thus far however there is little agreement regarding causes.

Disposition of the muscles

Is the sclera extensible and are the muscles appropriately placed so to extend it?

The sclera, the eye's tough outer tunic, possesses elastic fibres around the optic nerve, around the equator of the globe and in abundance *immediately behind the cornea*. It is thickest posteriorly (1 mm) and gradually becomes thinner anteriorly, here being only 0.3 mm thick. It is into this thinner region that four of the eye's six external muscles (the rectus muscles) are inserted, all within a few millimetres of the cornea. The fibres of these muscles enter the sclera in parallel and then fan out to become lost in the meridional fibres of the sclera.

Whereas the rectus muscles are inserted into the *thinnest* region of the sclera, the other two muscles (the obliques) are inserted laterally into the *thicker*, posterior region of the globe. As with

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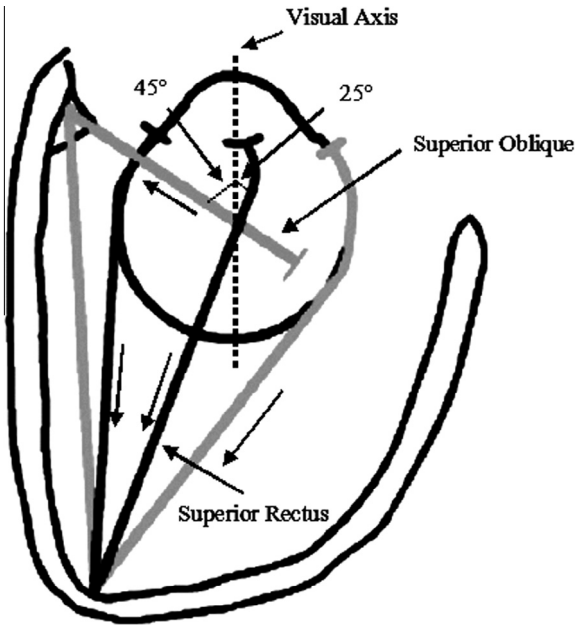

Fig. 1. Angular disposition of the muscles. Right eye viewed from above, visual axis directed straight ahead for distance vision.

the recti, the fibres enter the sclera in parallel and then lose themselves amongst the oblique and equatorial fibres of this region of the sclera.

The two vertical recti (superior and inferior) are at an angle of about 25° to the visual axis and the two obliques at an angle of 45°. It is of importance to note here that *the traction of all four recti is from in front backwards,* towards the rear of the socket, while *that of the obliques* is *from behind forwards*, towards the nasal wall of the socket, and hence *opposed* to that of the recti, as indicated by the arrows Fig. 1.

The points of insertion in the sclera of the two obliques are not far apart and together these two muscles form a nearly continuous band round the eyeball (Fig. 2). Thus they contribute to its support, *somewhat in the manner of a sling.*

The action of the muscles

The manner in which the external muscles of the two eyes cooperate to turn the eyes in all directions is somewhat complicated and need not concern us here. Suffice it to differentiate between *conjugate* movements, in which the axes of the two eyes are parallel, and *disjugate* movements, in which the axes incline either towards or away from each other. Here we are concerned with one action only – the disjugate movement of *convergence*, wherein the gaze is transferred from a far to a near object, and where the eyes must at the same time *accommodate* – that is, increase their focal power.

It is to be noted that the eyeball is not a perfect sphere (the a-p, transverse and vertical diameters being, respectively 24, 23.5 and 23 mm). The point about which the muscles rotate the eyeball is *not* in fact the true centre of the globe; this point is slightly closer to the retina than to the front of the eyeball, and may be thought of as the centre of a hypothetical sphere (see Fig. 3, below). Thus the anterior region of the sclera, ciliary body, iris and cornea are all situated relatively anterior to this sphere. In conjugate movements, in which the eye is rotated freely in all directions as in a ball-and-socket joint, these relatively anterior structures do not participate. *By contrast, these forward structures are intimately involved in convergence* [Ref. [4] gives a full account].

Convergence

Fig. 3 shows again the right eye in its socket, directed straight ahead.

It will be appreciated at once that contraction of the *medial* rectus will turn the eye *inwards*. Not so obviously, this muscle is assisted in this action by the superior rectus (above the eyeball) and the inferior rectus (beneath). Note that all three adducting muscles (convergers) pull *from in front backwards*.

The abducting muscles (or divergers), are the external rectus and the two obliques. Again it is easy to see that contraction of the *external* rectus will turn the eye *outwards*. It is assisted in this action – not so readily apparent – by the superior oblique (above the globe) and the inferior oblique (beneath). Note that these two muscles pull *from behind forwards*. When the eye is directed

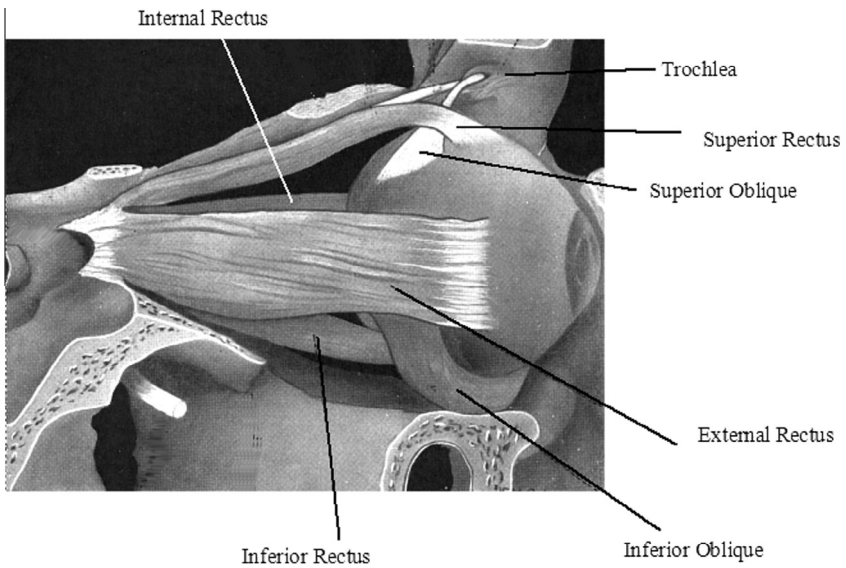

Fig. 2. Dissection to show the ocular muscles of the right eye from the lateral aspect [From E. Wolff – 'The Anatomy of the Eye and Orbit', 1968].