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# EXTRAOCULAR MUSCLES ANATOMY AND PHYSIOLOGY

## THESIS

Submitted in Partial Fulfilment  
of the Master Degree in  
(OPHTHAIMOLOGY)



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GROSS ANATOMY  
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GROSS  
ANATOMY OF EXTRAOCULAR  
MUSCLES

The gross anatomy of the extraocular muscles and other orbital structures was fairly understood in ancient times. Galen (130-200 A.D.), described the six muscles, four to move the eye horizontally and vertically and two to rotate it. His description of oblique muscles was extremely inaccurate. Gabriello Fallopio (1561) gave the first reasonably and detailed description (Duke Elder 1973).

This knowledge was refined during the renaissance and further enlarged upon, notably by Whitnal and Motias, during the first part of this century. The outstanding figure during our time was Walter fink, whose contributions to the surgical anatomy of extracocular muscles formed the basis for a more aggressive surgical approach to treating cyclo-vertical muscle problems and, thus, for more effective therapy of clinical conditions thought in the past to be incurable. (Noorden, 1978).

Rotation of each globe is controlled by three pairs of extraocular muscles: a pair of horizontal rectus

muscles, a pair of vertical rectus muscles, and a pair of oblique muscles.

### The Rectus Muscles

The rectus muscles are more or less flat, narrow bands that attach themselves with broad, thin tendons to the globe. They are four in number: the medial (internal), lateral(external), superior, and inferior rectus muscles.

The four rectus muscles arise from a common origin at the apex of the orbit, and as they run forwards to be inserted into the eye ball, they diverge to form a "muscle cone" surrounding the posterior part of the globe and the optic nerve.

The common origin takes the form of a complete ring, the ANNULUS of ZINN (1755), which encircles the optic foramen and the medial end of the superior orbital fissure.

Through the annulus all the structures entering the orbit by way of the optic canal, and lower part of the superior orbital fissure must necessarily pass.

It is interesting to note that the original description of the structure by Zinn (1755) referred

to a ligament which is confined to the lower part of the apex of the orbit but this description was amplified by Lockwood (1886), who described The upper part of the ligament.

The lower tendon (of Zinn) is attached to the inferior root of the lesser wing of the sphenoid between the optic foramen and the superior orbital fissure. This tendon gives origin to part of the medial and lateral recti and the whole of the inferior.

The upper tendon (of lockwood) arises from the body of the sphenoid, and gives origin to part of the medial and lateral recti and the whole of the superior.

The medial and lateral rectus muscles follow the corresponding walls of the orbit for a good part of their course, while the inferior rectus muscle remains in contact with the orbital floor for only about one half of its length. The superior rectus muscle is separated from the roof of the orbit by the levator muscle of the upper lid.

If the rectus muscles were to continue their course in their original direction, they would not touch the globe. Somewhat in front of the equator

they turn toward the eyeball in a gentle curve and insert on the sclera at varying distances from the corneal limbus.

Abnormal Insertions:

1. **Secondary Insertions.** Charpy (1912) described how recurrent fibres may detach themselves from the bulbar side of the rectus muscles near their insertion, attaching themselves to the sclera 1 to 5 mm behind the insertions.

2. **Foot-plate Insertions**

According to scobee (1948), the foot-plate type of insertion is occasionally encountered. In this condition, the line of insertion of the muscle at the usual distance from the limbus appears to be normal both in length and in direction. However, when the linear insertion of the muscle is severed, the muscle will be found to be attached to the globe backward from its linear insertion for a distance varying from 2 to 7 mm.

3. **Abnormal Muscle Slips**

Scobee (1948) states, "Abnormal muscle slips may either arise well back in the orbit and diverge

slightly from the course of rectus muscle, which is their apparent source, to become inserted into the globe at a point somewhat behind and to one side of the insertion of their parent muscle, or an abnormally large collection of muscle fibres will be found in the intermuscular membrane. The latter condition is by far the more common of the two. Abnormal muscle slips appear in association with the rectus muscles in the following order of frequency (1) superior rectus, (2) lateral rectus, (3) Medial rectus, and (4) inferior rectus.

The insertions into the sclera are made by glistening tendons whose fibres run almost entirely parallel to the long axis of the muscle. These fibres consist of fibrous tissue supported by thick elastic fibres. Apart from their size they resemble the scleral fibres, being made of the same tissue. But whereas the tendon fibres are practically all longitudinal, the scleral fibres run in many directions. This results in the tendon having a glistening, silky appearance while the sclera is dull white (Fink, 1950).

Since the insertions of the rectus muscles are not equidistant from the corneal limbus, they do not lie on a circle concentric with it but lie on a spiral

ABNORMAL MUSCLE INSERTION

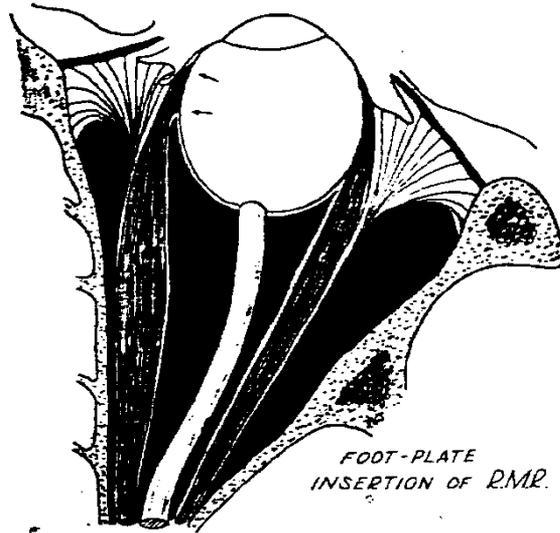


Fig. —Schematic drawing illustrating a foot plate insertion. (Scobee: *American Journal of Ophthalmology*, December, 1948, pp. 1539-53.)

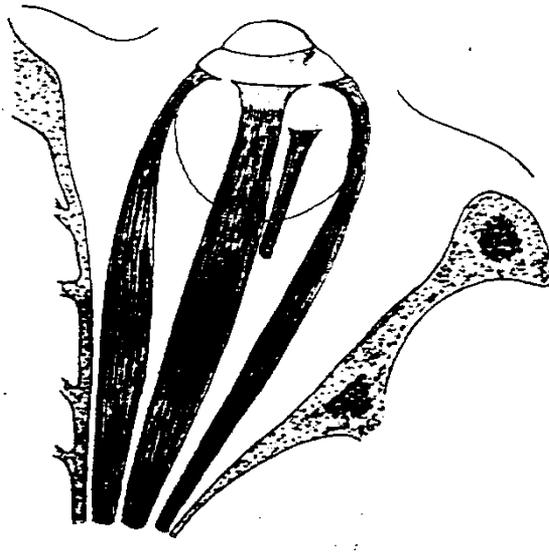


Fig. —Schematic drawing illustrating an anomalous muscle slip. (Scobee: *American Journal of Ophthalmology*, December, 1948, pp. 1539-53.)

(The spiral of Tillaux). The insertion of the medial rectus muscle is closest to the corneal limbus, followed by the inferior, lateral, and superior rectus insertions, the superior rectus insertion being the most distant (Wolff, 1976).

The lines of insertion are generally not straight but are more or less curved and sometimes even wavy. The straightest ones are the insertions of the medial and lateral rectus muscles, but these two are frequently slightly convex toward the corneal limbus. Fuchs (1894) found in 50 cadaver eyes that in one half of the cases the horizontal meridian cut the insertions symmetrically. For the rest of cases, up to two thirds of the width of the tendon of the medial rectus muscle was above the horizontal meridian and that of the lateral rectus muscle was below it. Fuch's (1894) found also that the insertion line of these muscles was perpendicular to the horizontal meridian in less than one half of the eyes. In the others the insertion lines ran obliquely-up and in in-the case of the medial rectus and up and out in the case of the lateral rectus.

The lines of insertion of the superior and inferior rectus muscle are markedly convex toward the corneal limbus and run obliquely upward and laterally.

The rounded, temporal ends of their insertions, therefore, are more distant from the corneal limbus than their nasal end. The amount of obliquity varies in different eyes but is usually marked and, according to fuchs, is usually of the same degree for the two muscles of the same eye. The lines of insertion are cut asymmetrically by the vertical meridian. The greater part of the tendon (two thirds of its width) of the superior rectus lies temporally to the meridian. In one third of the eyes, Fuchs (1894) found that the meridian bisected the inferior rectus tendon; otherwise, the larger segment of the insertion line was found to lie laterally to it.

#### The Superior Rectus

The superior rectus arises from the upper part of the annulus of Zinn, above and to the outer side of the optic foramen and from the sheath of the optic nerve. The muscle passes forward and outward beneath the levator, making an angle of  $25^{\circ}$  with the visual line. Piercing the fascia bulbi, it is inserted into the sclera 7.7 mm from the limbus by a tendon 5.8 mm long. The line of insertion is oblique, 10.8 mm long, and curved so as to be slightly convex forward. The muscle is about 42 mm in length and 9 mm in width.

It is supplied by the superior division of oculomotor nerve which enters the undersurface of the muscle at the junction of its middle and posterior thirds. Its blood supply comes from the lateral muscular branch of the ophthalmic artery. (Wolff, 1976).

#### The Inferior Rectus

The inferior rectus is the shortest of the rectus muscles. It arises below the optic foramen, from the middle slip of the lower common tendon. It passes forward and outward along the floor of the orbit, making an angle of  $25^{\circ}$  with the visual line, and is inserted into the sclera 6.5 mm. from the limbus by a tendon 5.5 mm. in length. It is about 40 mm. in length and 9 mm. width. The line of insertion is 9.8 mm. long, markedly convex forward, always somewhat oblique, so that the nasal end lies nearer the limbus. It is supplied by the inferior division of the third nerve, which enters the muscle on its upper aspect at about the junction of the middle and posterior third. Its blood supply comes from the inferior muscular branch of the ophthalmic artery. (Wolff, 1976).