

USES OF BOTULINUM TOXINS IN OPHTHALMOLOGY

ESSAY

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the M.Sc. Degree in **Ophthalmology**

By

617.7061
H. M

Hussam El-Din Moustafa Kamel

M.B., B.Ch.

Under supervision of

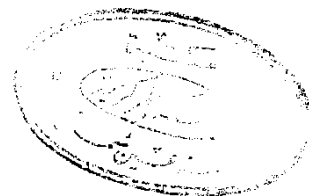
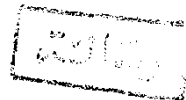
Prof. Dr. Hamed Abd El-Hamid Rabie

Professor of Ophthalmology

Faculty of Medicine

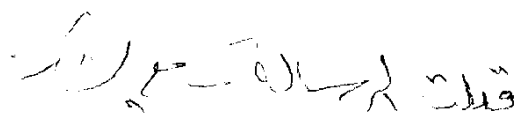
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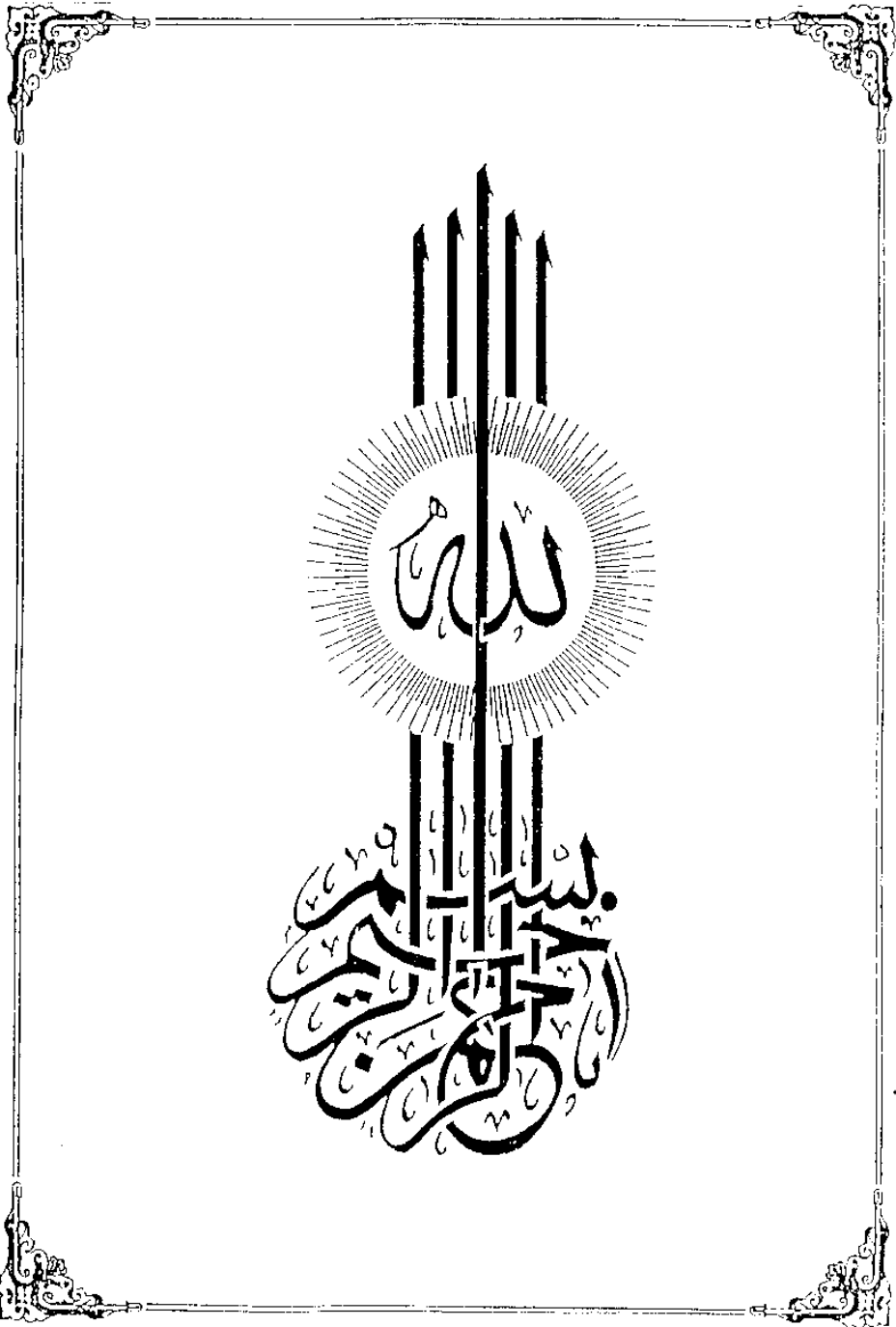
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LIST OF ABBREVIATIONS

ACHE	= Acetyl choline esterase.
DFP	= Di-isopropyl-fluorophosphate.
IO	= Inferior oblique.
IR	= Inferior rectus.
LR	= Lateral rectus.
MR	= Medial rectus.
PD	= Prism diopters.
SO	= Superior oblique.
SR	= Superior rectus.
-S-S-bonds	= Disulphide bonds.

CHAPTER I
ANATOMY AND PHYSIOLOGY
OF EXTRINSIC MUSCLES OF
THE EYE

CHAPTER I

ANATOMY OF THE EXTRA-OCULAR MUSCLES

The extra-ocular muscles include four rectus muscles and two oblique muscles. The rectus muscles originate from a fibrous ring at the orbital apex, called the annulus of Zinn. The annulus of Zinn is oval on cross-section and encircles the optic foramen and the medial part of the superior orbital fissure. The lateral part of the annulus is attached to the spina recti lateralis which is a small bony projection at the anterior margin of the superior orbital fissure (*Warwick, 1976*). The annulus of Zinn is formed of two portions. The lower portion (tendon of Zinn) gives origin to the inferior rectus and the inferior portions of the medial and lateral rectus muscles. The upper portion (tendon of Lockwood) arises from the body of the sphenoid bone. It gives origin to the superior rectus and the superior portions of the medial and lateral rectus muscles. The tendon of Zinn is more developed than the tendon of Lockwood (*Doxanas and anderson, 1984*) (Fig.1).

The superior rectus muscle is separated from the roof of the orbit by the levator muscle of the upper lid. In front of the equator, the recti muscles turn toward the eyeball in a gentle curve and are inserted into the sclera by tendons of different widths and at different distances from the limbus (*Warwick, 1976*). The lengths of the tendons of the rectus muscles, widths

of their insertions, and distances of insertion from the limbus are summarized in Table 1.

Insertions of the rectus muscles are not equidistant from the limbus, they lie on a spiral (the spiral of tillaux). (*Kestenbaum, 1963*) (Fig.2).

Table 1: Comparative measurements of the rectus muscles.

	Distance between insertion and the limbus	Length of tendon	Width of tendon
Superior rectus	7.7 mm	5.8 mm	10.8 mm
Inferior rectus	6.5 mm	5.5 mm	9.8 mm
Medial rectus	5.5 mm	3.7 mm	10.3 mm
Lateral rectus	6.9 mm	8.8 mm	9.2 mm

(*Quoted from Warwick, 1976*).

With regard to the length of the rectus muscles, which is somewhere about 40mm, the superior is the longest, then the medial, then the lateral. The inferior rectus is the shortest (*Warwick, 1976*). In the primary position, the planes of the superior and inferior rectus muscles form an angle of 23° with the visual axis (*Doxanas and anderson, 1984*).

The superior oblique muscle is the longest and thinnest extra-ocular muscle. It originates from the periosteum of the body of the sphenoid bone above and medial to the annulus of

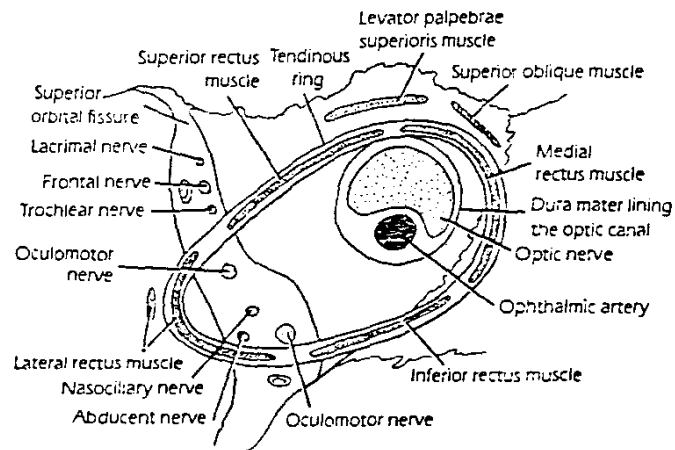


Fig.1: The apical region of the right orbit.
(Quoted from Snell and Lemp, 1989).

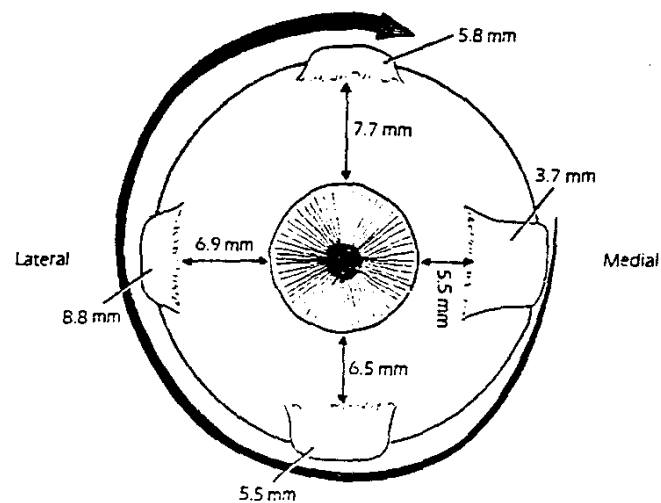


Fig.2: The right eyeball as seen from front.
(Quoted from Snell and Lemp, 1989).

Zinn by a narrow tendon (*Fink, 1947*). The muscle belly is fusiform and runs forwards between the roof and the medial wall of the orbit. About 1cm behind the trochlea, it becomes a rounded tendon, which hooks around the trochlea and is surrounded by a delicate synovial sheath. Then, it turns downwards, backwards, and laterally at an angle of about 54° with the visual axis (the trochlear angle), passing under the superior rectus and spreading out in a fan-shaped manner to be inserted into the sclera in the postero-superior quadrant lateral to the mid-vertical plane (*Kestenbaum, 1963*).

The inferior oblique originates from a small depression on the orbital plate of the maxilla a little behind the lower orbital margin and just lateral to the opening of the nasolacrimal duct (*Fink, 1947*). It runs backwards and laterally at an angle of about 51° with the visual axis between the inferior rectus and the floor of the orbit, then curves round the eyeball to lie underneath the lower border of the lateral rectus. It is inserted by a very short tendon (Often none at all) to the back and lateral portion of the globe, for the most part below the horizontal meridian (*Kestenbaum, 1963*). Nasal end of the insertion lies only 2.2mm. from the Fovea. The length of the inferior oblique is about 37mm. (*Warwick, 1976*).

Nerve supply:

All extra-ocular muscles, except the lateral rectus and the superior oblique, are innervated by the oculomotor nerve. The superior division of the oculomotor nerve supplies the superior rectus, while the inferior division supplies the medial rectus, inferior rectus, and inferior oblique muscles. The lateral rectus is supplied by the abducent nerve, while the superior oblique is supplied by the trochlear nerve. The motor nerve to each rectus muscle enters the muscle from its internal (bulbar) surface at approximately the junction of the middle and posterior thirds of the muscle. The superior oblique is supplied by its nerve in several branches that enter the anterior half of the posterior third of the muscle, on its outer (orbital) surface. The inferior oblique is supplied at about the middle of its posterior border (*Eggers, 1988*).

Blood supply:

All extra-ocular muscles are supplied by the lateral and medial muscular branches of the ophthalmic artery. The lateral branch supplies the lateral and superior rectus and superior oblique muscles. The medial branch, the larger of the two, supplies the medial and inferior rectus and inferior oblique muscles (*Koziol, 1980*). The infraorbital artery and the lacrimal artery share in the blood supply. The veins from the extra-ocular muscles correspond to the arteries and empty into the superior and inferior orbital veins (*Von Noorden, 1985*).

The Fascia Surrounding the Extra-ocular Muscles:

I. Sheaths of the Muscles:

From the origin of the muscles up to 2cm the sheath is very thin. From the level of the back of the globe, the muscle is enclosed in a thick, opaque sheath which represents a sleeve-like extension of Tenon's capsule. (*Warwick, 1976*).

Multiple fascial expansions exist between the sheath of the superior rectus and that of the levator palpebrae superioris, which serve to coordinate upward movement of the globe and upper eyelid (*Eggers, 1988*).

The inferior rectus is firmly attached to the inferior oblique by a fusion of their fascial sheaths, and this combined structure contributes to Lockwood's suspensory ligament (*Doxanas and Anderson, 1984*). This ligament is attached to the inferior tarsus by the capsulopalpebral fascia, a tissue analog of the levator aponeurosis in the lower lid. This ensures lowering of the lid on downgaze (*Eggers, 1988*).

II. Intermuscular Septum:

It is a fascial sheet of thin, avascular tissue extending from the muscle sheaths toward the nearest adjacent extra-ocular muscle (*Parks, 1988*). It forms a cone extending from its origin at the annulus of Zinn to its termination 1mm anterior to the tendinous insertion of the rectus muscles. The septum divides

the orbital fat into central and peripheral portions. The central portion lies within the muscular cone and is bound anteriorly by the posterior aspect of the globe, which is covered by another fascial membrane, Tenon's capsule. The peripheral portion of orbital fat is bound by the periorbita and orbital septum (*Koziol, 1980*).

III. Tenon's capsule:

It is a minimally vascular fascial layer of elastic connective tissue surrounding the eye and extra-ocular muscles and extending from the limbus to the optic nerve (*Parks, 1983*) (Fig.3) all the six extra-ocular muscles penetrate Tenon's capsule prior to their insertion into the globe. The four rectus muscles penetrate Tenon's capsule posterior to the equator while the two oblique muscles penetrate anterior to the equator of the globe. (*Doxanas and anderson, 1984*).

As the anterior Tenon's capsule and sub-Tenon's intermuscular septum approach within 3mm of the limbus, they fuse into a single fascial plane, which then joins with the conjunctiva 1mm peripheral to the limbus. Consequently, a limbal incision brings the surgeon immediately down to the sclera, leaving the conjunctiva, anterior Tenon's capsule, and sub-Tenon's intermuscular septum sealed together. Incisions remote from the limbus cut through these three tissues in separate layers (*Parks, 1983*).