A COMPARATIVE STUDY OF THE DIFFERENT METHODS OF WEAKENING PROCEDURES OF EXTRA-OCULAR MUSCLES

ESSAY

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Hoda Afifi

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بسم الله الرحمن الرحيم

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INTRODUCTION

INTRODUCTION

The aim of this essay is to review the different methods of the weakening procedures used in squint surgery. It is written as a comparative study to reach the most suitable method for each patient. The weakening procedures include myectomy, tenotomy (total and marginal), recession, controlled recession, augmented recession, recession and adhesive material and Botulinum toxin A.

The basic knowledge of anatomy and physiology of extra-ocular muscles were included.

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ANATOMY

Rotation of the globe is controlled by six extraocular muscles, four recti and two obliques.

Wolff (1976) stated that the four recti are attached posteriorly to a short tendinous ring (annulus tendineus communis of Zinn) which is oval in cross section and encloses the optic foramen and a part of the medial end of the superior orbital fissure. Its attachment to the anterior margin of the fissure is marked by the spina recti lateralis. The inner surface of the annulus is thickened in its upper and lower parts by strong bands or common tendons.

The lower tendon of Zinn : is attached to the inferior root of lesser wing of the sphenoid between the optic foramen and the superior orbital fissure. It gives origin to part of the medial rectus, part of the lateral rectus and the whole of the inferior rectus.

The upper tendon of Lockwood : arises from the body of sphenoid and gives origin to part of the medial and lateral recti and the whole of the superior rectus.

With regard to their length which is about 40 mm, the superior rectus is the longest, then the medial rectus, then the lateral rectus, then the inferior rectus which is the shortest. The recti extend anteriorly close to the wall of the orbit and get inserted into the sclera anterior to the rotation center of the globe by tendons of different lengths and widths at variable distances from the cornea. The motor nerve to each muscle enters the internal surface of the muscle approximately, at the junction of the posterior one third and anterior two-thirds (Wolff, 1976).

Medial rectus muscle

Its origin is from the upper and lower common tendons and from the sheath of the optic nerve (Wolff, 1976).

According to Parks (1983), it courses forward for 40 mm along the medial aspect of the globe, after penetrating Tenon's capsule approximately 12 mm from its insertion. It contacts the eye in the last 5 mm as it arcs to its insertion 5.3 mm from the cornea by a tendon 3.7 mm in length. The line of insertion is straight 10.3 mm in width. It is about 40 mm and is the largest of the ocular muscles in bulk. The terminal, tendinous portion of the muscle is only 4 mm long. Innervation is by the inferior division of oculomotor nerve which enters the muscle on its lateral deep surface about the junction of the middle and posterior thirds and its blood supply from the medial muscular branch of the ophthalmic artery.

Adduction is a horizontal movement directed medially from the vertical axis, it is primarily accomplished by contraction of the medial rectus muscle and relaxation of the lateral rectus muscle (Parks, 1983).

Lateral rectus

According to Wolff (1976), its origin is from the upper and lower common tendons from that part which crosses the superior orbital fissure. The origin is V or U shaped with the opening of the letter towards the optic foramen. It is attached also to the spina recti lateralis.

The lateral rectus muscle courses forward for 40 mm along the lateral aspect of the globe, after penetrating Tenon's capsule approximately 15 mm from its insertion, the muscle contacts the eye over the last 7 mm to 8 mm as it arcs to its insertion 6.9 mm from the cornea by a tendon 8.8 mm in length. The line of insertion is straight and is 9.2 mm in length. The terminal tendinous portion of the muscle is 9 mm long. Innervation is by the abducent nerve which enters the muscle on its medial surface just behind its middle. Its blood supply from the lacrimal artery and lateral muscular branch of ophthalmic artery.

Abduction is a horizontal movement directed laterally from the vertical axis. It is accomplished by contraction of the lateral rectus muscle and relaxation of the medial rectus muscle (Parks, 1983).

Superior rectus

Its origin is from the upper part of the annulus of Zinn and from the sheath of the optic nerve (Wolff, 1976).

According to Parks (1983), it courses forward for 42 mm along the dorsal aspect of the globe. Its axis makes an angle of 23 degrees with the vertical meridian when the eye is in the primary position. After penetrating Tenon's capsule approximately 15 mm from its insertion, contacts the eye for the last few millimeters as it arcs to its insertion, 7.7 mm from the cornea by a tendon 5.8 mm in length. The line of insertion is oblique, curved and its convexity forward and 10.8 mm in length. It is innervated by the superior division of the oculomotor nerve which enters the ocular surface of the muscle at the junction of the middle and posterior thirds. Its blood supply is from the lateral muscular branch of ophthalmic artery. The action of the muscle varies according to the eye's horizontal starting position. When the eye movement starts from a position of 23° of abduction, the only movement is elevation. When it starts from a position of 67° of adduction, the only movement is intorsion. When it starts from the primary position, the movement is combined elevation and intorsion plus slight adduction.

Inferior rectus

According to Wolff (1976), its origin is from the lower common tendon.

It courses forward for 40 mm along the ventral aspect of the globe, making an angle of 23 degree with the vertical meridian when the eye in the primary position. After penetrating Tenon's capsule approximately 15 mm from its insertion, the muscle contacts the eye over the last few millimeters as it arcs to its insertion 6.5 mm from the cornea by a tendon 5.5 mm in length. The line of insertion is oblique convex forwards and 9.8 mm long. It is also inserted to the lower lid by fascial expansions of its sheath. Innervation is by the inferior division of oculomotor nerve which enters its ocular surface at the junction of its middle and posterior thirds. Its blood supply is from the medial muscular branch of the ophthalmic artery. Its action varies according to the eye's horizontal starting position. When the eye movement starts from a position of 23° of abduction, the only movement is depression. When it starts from a position of 67° of adduction, the only movement is extorsion. When it starts from the primary position, the movement is combind depression and extortion plus slight adduction.

The Superior oblique

According to Parks (1983), it originates from above and medial to the optic foramen, coursing anteriorly between the roof and medial wall of the orbit, for approximately 40 mm to the trochlea. The muscle becomes tendinous approximately 9 mm posterior to the trochlea. Within the trochlea are 4 mm of tendon that run posteriorly at an angle of 55° to the nasal wall of the orbit before inserting on the posterior temporal superior quadrant of the globe ventral to the superior rectus muscle. The reflected tendon which is approximately 20 mm in length penetrates Tenon's capsule at its midpoint. The line of insertion is 10.7 mm convex posterioly and laterally. The trochlea is considered as the functional origin of the muscle. The insertion is behind the equator between the superior rectus and lateral rectus. The trochlear half of the reflected tendon passes through the fat cushion external to the muscle cone before penetrating Tenon's capsule. Loose tissue connects the inner surface of the trochlea and the tendon capsule. The insertional half of the reflected tendon becomes sub-Tenon's approximately 3 mm nasal to the medial border of the superior rectus muscle. The most posterior end of the superior oblique tendon insertion is approximately 5 mm from the optic nerve, and immediately temporal to the superior temporal vortex vein exit from the sclera. The tendon retains its capsule all the way down to the scleral insertion, even-though it is tissue-paper thin at this point. Despite the thiness of the tendon's terminal 4 mm, the individual fibres that splay out to the broad insertion are strong. Its action varies according to the eye's horizontal starting position. When the eye's movement starts from a position of 39° of abduction, the only movement is intorsion. When it starts from a position of 51° of adduction, the only movement is depression. When it starts from the primary position, the movement is combined intortion and depression, plus slight abduction. It is innervated by the trochlear nerve, after dividing into 3-4 branches it enters the muscle superiorly and near its lateral border. The most anterior branch is at the junction of the middle and posterior thirds and the most posterior is 8 mm from its origin. Its blood supply is from the lateral muscular branch of ophthalmic artery.

The Inferior oblique

According to Parks (1983), it originates from the orbital plate of the maxilla a little behind the lower orbital margin just lateral to the opening of the nasolacrimal duct, few fibres take origin from the lacrimal fascia. Courses backwards and temporally at a 51° angle with the nasal orbital wall and penetrates Tenon's capsule near the ventral surface of the inferior rectus muscle. It arcs laterally and posteriorly around the globe to insert into the sclera under the lateral rectus muscle just anterior to the macular area. The line of insertion is oblique convex up and 9.4 mm in length and 5-14 mm in width. The nasal end of the line of insertion is about 5 mm from the optic nerve and thus lies practically over the macula (only 2 mm from it). The total length of the muscle is 37 mm, with a very short or no tendon which is less than 1 mm in length, so it is almost wholly muscular unlike other muscles specially superior oblique (Wolff, 1976). It is innervated by the inferior division of oculomotor. The nerve enters the inferior oblique muscle approximately 15 mm from its insertion along the posterior lateral border on its scleral side. Its blood supply is from the infraorbital artery and medial muscular branch of ophthalmic artery. Its action varies according to the eye's horizontal starting position. Thus, when the eye movement starts from a position of 39° of abduction, the only movement is extorsion. When it starts from a position of 51° of adduction, the only movement is elevation. When it starts from the primary position, the movement is combined extorsion and elevation plus slight abduction.

Histology and electron microscopy

According to Wolff (1976), the extraocular muscles are as those derived from the branchial arches, and are more highly differentiated than any other muscles in the body in some respects. Instead of being grouped together in bundles separated by dense connective tissue, the fine fibres are loosely united and hence easily separated by dissection. In the intervals between the fibers are numerous nerve fibres. Each muscle fibre has a diameter of 9-30 µm, being less than in other striated muscles. Each fibre is surrounded by a sarcolemma surrounding a granular sarcoplasm in which myofibrils may be seen. This gives the cross-section of the fibril a punctiform appearance. In such a section at least one nucleus is usually visible just internal to the sarcolemma. Each muscle fiber or cell is of course a multinucleated structure. There are at least two and perhaps more types of muscle fibres in the extra-ocular muscles. Thin fibres (9-11µm) form a less numerous group chiefly distributed peripherally and sometimes known as "slow fibres". The fibres have grape-like motor nerve terminals. The largest group, the so called "twitch" fibres are of the order of 11-15µm, and these have plaque-like motor nerve endings. The "slow" and "twitch" fibres exhibit considerable ultrastructural details in their endoplastic reticulum and tubule systems and they also differ in pharmacological responses (Davson,1969 and Bachy-Rita, 1971). The connective tissue around the fibres constitutes the endomysium and contains a large quantity of elastic tissue arranged longitudinally. Similar septa surround a number of muscle fibres are called the internal perimysium. These septa contain large elastic fibres, the vessels and nerves, and some connective tissue cells. The internal perimysium is continuous with the external perimysium, or epimysium which surrounds the muscle. The extraocular muscles are peculiar in the large number of nerve and elastic fibres which they contain. Each motor neuron supplies relatively few muscle fibres.

The sheaths of the muscles: From the origin for two centimetres the sheath is practically non-existent, being very thin and transparent so that the macroscopic structure of the muscle is easily visible. Then it becomes thicker, opaque and disposed in two layers, the outer or orbital layer with circular fibres and the inner with longitudinal fibres. The inner layer is continous with the internal perimysium (Wolff, 1976).

Buzzard (1908) described and figured muscle spindles in the eye muscles of man. He knew they were proprioceptive in function. Yet for many years this was overlooked and the spindles were not seen.

Woollard (1931) described fine non-medullated fibres to the ocular muscles, seen in stained sections and he wondered if they were sensory but he failed to see or mention muscle spindles.

Daniel (1946), Cooper and Daniel (1949) and Cooper (1951) again described muscle spindles. They are however only found in