

EXTRAOCULAR MUSCLES IN SOME MAMMALS HISTOLOGICAL AND HISTOCHEMICAL STUDY

THESIS

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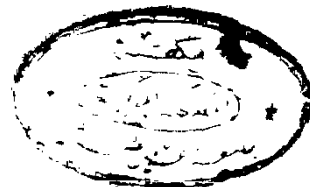
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INTRODUCTION & AIM OF THE WORK

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INTRODUCTION
AND AIM OF WORK

Since 1882 or even before that, attention had been directed towards the study of mammalian extraocular muscles. Most of the early studies concerned the morphological structure and innervation pattern of these muscles (Marchi, 1882; Sherrington, 1897; and Wohlfart, 1938).

Physiological studies revealed the presence of two types of fibres in these muscles, very slow and very fast and the latter type made the extraocular muscles among the fastest vertebrate muscles (Brown and Harvey, 1941; and Hess and Pilar, 1963).

Many investigations were done to study the various characteristics of this specific type of muscles by the help of electron microscope and using advanced histochemical techniques (Mayr, 1971; Harker, 1972; Nag and Peachy, 1972; Alvarado and Van Horn, 1975; and Pachter et al., 1976). These studies had shown the presence of five distinctive fibre types in different mammalian extraocular muscles.

REVIEW OF LITERATURE

REVIEW OF LITERATURES

Marchi (1882) demonstrated Golgi's tendon spindles in the eye muscles of ox, at the transition between muscle and tendon. He identified similar spindles in the pig, but he had great difficulty in finding them in the dog, rabbit and man.

Retzius (1892) was the first to describe terminations en grappe in the extraocular muscles of rabbit as a typical motor nerve endings. These were designed as terminals of fibres, myelinated or nonmyelinated coursing longitudinally with the muscle fibre.

Sherrington (1897) investigated the innervation of the extraocular muscles of the cat. He reported a peculiar branching about the tendons or at the tendon ends of the muscles. These nerve endings were not disturbed by section of the ophthalmic division of the fifth cranial nerve, and were destroyed only by section of the motor nerve of the muscle. However, when both opnthalmic division of the fifth, and sixth cranial nerves were cut, the external rectus contained nothing but degenerate nerve fibres and few fine myelinated fibres which he thought propaoly took their origin in the ciliary ganglion.

Sherrington (1898) obtained similar results when he investigated the innervation of extraocular muscles of monkey.

Huber (1899) described en grappe endings in the extraocular muscles of the rabbit, but he concluded that they were sensory endings and not motor.

Huber (1900) showed the same en grappe endings in the extraocular muscles of the cat. In addition to his conclusion that they were sensory he described sensory nerve endings in the tendon ends of the muscles.

Crevatin (1901) showed Golgi tendon organs, not tendon spindles, in human extraocular recti muscles, as well as a few muscle spindles.

In 1902 Crevatin studied the extraocular muscles of the camel, using gold chloride. He described typical motor endings but did not picture them. He showed also filamentous varicosities, very similar to terminal endings lying on muscle fibres with very small diameter. These endings were supplemented by terminations at the transition between tendon and muscle and by complicated endings in the tendon itself.

Schiefferdecker (1904) described the large amount of

connective tissue lying between the muscle fibres in human eye muscles, giving the section a characteristic appearance. He added that much of it was made up of elastic fibres and that the function of these was to bring the muscle back to its resting length. The considerable quantity of connective tissue around muscle fibres of eye muscles was one of the factors which had prevented the recognition of the capsules of muscle spindles.

Dogiel (1906a, b) investigated the extraocular muscles of man, monkey, horse, ox, dog and cat. He demonstrated nerve endings in the intermuscular connective tissue and showed that terminations in the eye muscles of ox were very much developed and of greater number than in man, monkey, dog or cat. In the horse, only modified pacinian corpuscles, somewhat similar to tendon spindles, were found. Also, nerve terminations at the transition between the muscle fibre and tendon originated sometimes from a heavily medullated fibre and other times from a thinly medullated fibre, both of which possibly sent a branch as a termination en grappe to the muscle fibre itself. The heavily medullated nerve fibres appeared sending off a great number of branches to the muscle fibre, while the thinly medullated fibres gave rise to non medullated fibres which in turn ended as simple terminations, often resembling termination en grappe.

Cilimbaris (1910) could not find muscle spindles in the extraocular muscles of dog, cat, rabbit, horse, fox or rat, but he described them in sheep, goat and wild pig. He also found that the number of intrafusal fibres varied from 3 to 15 fibres. These spindle fibres branched dichotomously and formed anastomosis with other spindle fibres, and within the spindles, both sarcoplasm rich and sarcoplasm poor muscle fibres were recognized. In the former the nuclei were centrally placed. The nerve endings on the muscle fibre were similar to the classical description for spindles. The thicker or larger nerve fibres ended with spiral-like or bulbous terminations upon the equatorial region of the muscle fibre. Away from the centre of the spindle, a thin nerve fibre came to an end as a termination en grappe. Some times, two nerve endings were found at the equator, with occasional slender nerve fibre passing to an extrafusal fibre and other times the two nerve fibres appeared at the equator with double polar endings.

Boeke (1913) examined the extraocular muscles of the cat. He detected, on some muscle fibres, a non medullated nerve fibre which was accessory to the medullated motor end plate and on others, similar fibres (non medullated) were found independently on muscle fibres of small diameter. He also showed that if 3 weeks were given for somatic degeneration, the greater part of these non medullated fibres had disappeared leaving a few intact.

When the reverse experiment i.e. sympathetic degeneration, was performed, he observed only a decrease in the number of accessory fibres.

Sutton (1915) described structures which he reported to be muscle spindles in the extraocular muscles of the embryo of pig. However, the details of their nervous structure were not found afterbirth.

Garven (1925) presented many important observations upon the extraocular muscles of the rabbit. He found that the muscle fibres showed variation in diameter and in the amount of longitudinal striations, to the degree that they can not be classified into two definite types. He also found that the Rouget end plates arising from myelinated nerves were found alike on thick and thin muscle fibres. They were found mainly in the posterior part of the muscle. Also, the sensory terminations were recognized in its anterior part.

Woollard (1927) studied the extraocular muscles of rabbit and he identified 2 sizes of fibres. Larger ones were innervated by medullated nerve fibres and small fibres were innervated by non medullated nerve fibres. He believed that this type of double innervation was unique to the extraocular muscles. The non medullated fibre ended as a termination en grappe and was

therefore epilemmal, resembling the older descriptions of sensory endings. However, he stated that this fibre and its ending were not to be confused with the sensory endings on the muscle fibres. Also, he had never seen both a medullated and a non medullated nerve fibres on the same muscle fibre or a small muscle fibre with a typical hypolemmal motor end plate.

Stibbe, in 1929, pointed out that, in human foetus the sixth cranial nerve was as big as the inferior gluteal nerve, although the gluteus maximus muscle is 74 times as heavy as the lateral rectus muscle. So, the sixth cranial nerve, relative to its muscle, is the largest nerve in the human body.

Hines (1931) classified nerve endings in the extraocular muscles of rabbit into 4 morphologically distinct types. These were : terminations en grappe, naked endings, accessory terminations and motor end plates. He found that the grape like endings originated from heavily medullated nerve fibre and from non medullated axis cylinders which shared in common with the motor end plate a medullated nerve fibre. The naked terminations were branches of medullated nerve fibres, or continuation of non medullated axis cylinders which, coursing parallel to the muscle fibre, ended nakedly upon it. The accessory terminals were called accessory because they were nerve terminations upon a muscle fibre innervated also by a motor end plate. He

added that these endings might be epilemmal or hypolemmal and were characteristic of the middle third of the rabbit's extraocular muscles. To be added also that unaccompanied motor end plates occurred commonly in the proximal third near the origin.

Tarkhan (1934) studied the innervation of extraocular muscles of the cat. He cut the oculomotor and trochlear nerves at their exit from the brain. He found degeneration of all sensory and motor nerve fibres and endings in the muscles supplied, except for very minute fibres, which he considered them arising from cells distal to the cut. He concluded that they were not numerous enough to account for proprioception. Thus he considered that these nerves were mixed. He also suggested that fibres from these nerves ran in the tectospinal tract to the mesencephalic nucleus of the fifth nerve.

Irvine (1936) described some histological characteristics of the eye muscles of man, which appeared to be composed of parallel cross striated muscle fibres and all the fibres occupied the full length of the muscle. The muscle fibres appeared small in diameter compared with those of other somatic muscles but might vary greatly within limits.

Wohlfart (1938) studied the diameter of the muscle fibres of the extraocular muscles in man. They were found to be small

and varied in size from 10 - 50 micrometer across. He also detected Ringbinden, which appeared as bands or rings of cross striated fibre encircling the longitudinal muscle fibres. He described them in extrinsic eye muscles as being frequently present and attributed them as an aging process.

Corbin and Oliver (1942) destroyed the mesencephalic root and nucleus of the fifth cranial nerve in the cat. They found that there were no degenerated myelinated fibres in the third, fourth or sixth cranial nerves. They also destroyed the nucleus of the fourth nerve and found that all nerve endings in the superior oblique were degenerated. Therefore, they concluded that the cells of origin of the grape like endings were probably intermingled with the motor cells of the oculomotor nerve and did not end in the mesencephalic nucleus. Thus nerve fibres to and from all types of nerve endings in the extrinsic eye muscles ran together in the oculomotor nerves and probably originated or end in the nuclei of these nerves.

Daniel (1946) demonstrated nerve fibres encircling a single extrafusal muscle fibre present in the midzone of human extraocular muscles. He classified them into simple spirals and complex spirals. Simple spirals were represented as myelinated nerve fibres taking about 3 - 8 spiral turns around single small muscle fibres to end in fine finger like processes in