

HISTOLOGICAL STRUCTURE OF THE RETRACTOR PENIS MUSCLE OF THE DOG

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FOUR FIGURES (TWO PLATES)

During the past few years, physiologists and chemists have been working with the retractor penis muscle of various animals, chiefly of the dog. The muscle has in every case been regarded by these workers as composed of non-striated fibers. The results obtained in these investigations have been discordant, differing in some regards from the customary reactions, both physiological and chemical, of other smooth muscles. At the suggestion of Dr. Charles D. Snyder, this study of the histology of the retractor penis muscle was undertaken, for it was felt that any theories of smooth muscle contraction, arising from a study of this retractor muscle, must be based upon an established histology.

The retractor penis muscle in the dog is a cord-like structure, pale and translucent in its anterior portion but somewhat darker and more fleshy in its posterior fraction. It has its origin by two separate bundles of fibers, one from each side of the sphincter ani muscle. These bundles pass ventrally and at a distance of about 1 cm. from the sphincter join in the median plane and run forward over the ventral surface of the corpus spongiosum to the base of the glans where the fused bundles are inserted into the corpus spongiosum. In the medium-sized dog of 6 to 10 kilograms, the muscle has a length of about 50 mm. while its diameter is about 3 mm. throughout its whole extent. The muscle is surrounded by a dense fibrous sheath, continuous with the fascia covering the sphincter. On both sides of this are the bulbocavernosus muscles; these are attached partly into the sheath of the retractor penis muscle and partly into the

fibrous tissue of a median raphe on the ventral side of that muscle.

In this study the retractor penis muscles of five adult dogs and of one puppy were examined. The muscles were removed, fixed in Bouin's picro-formalin-acetic fluid and embedded in paraffin. The sections were stained in hematoxylin and eosin, iron hematoxylin and Mallory's connective tissue stain. One muscle was cut serially and another was removed with the adjacent part of the bulbocavernosus intact; this block was sectioned for the purpose of determining the relations of the two muscles. Representative sections were examined from different parts of the other retractor muscles.

A study of the sections showed in every instance that the retractor muscle is mixed, i.e., composed of both smooth and striated fibers. The anterior three-fifths of the muscle is composed entirely of smooth fibers (fig. 1) while the posterior two-fifths is made up of fibers of both types (fig. 3). The number of striated fibers in the posterior part is variable but their presence is constant. The proportion of striped muscle varied in the specimens studied from one-third to one-half. The proportion of striated fibers was least in the muscle from the puppy.

A characteristic field in the anterior part of the muscle (figs. 1 and 2) shows large spindle-shaped smooth muscle cells varying in none of the essential features from the usual text-book descriptions. The cells for the most part have their long axes parallel to the long axis of the muscle but there is some tendency to interlacing of the fibers and bundles of fibers (figs. 1). With Mallory's connective tissue stain the muscle plasma takes the characteristic red color. Sections treated with this stain show the amount of connective tissue to be abundant. This tissue is partly of the white fibrous variety, but there is distributed throughout a relatively great number of elastic fibers. In certain of the sections (fig. 2) these fibers have an undulating, wavy appearance. The nuclei of many of the smooth muscle cells in such a region tend to assume spiral forms. McGill ('09) has described this phenomenon in smooth muscle from the walls of arteries and has reviewed the literature on the subject

particularly in regard to its cause and significance. The spiral form may be due, as is suggested, to the "active or passive" contraction of the muscle cells, or it may be related to the shortening of the elastic tissue. While the cause of these spiral nuclei cannot be determined from the evidence at hand, it may be noted that in the tissues in which McGill described the phenomenon, there is also associated with the muscle element a relatively large amount of elastic tissue. In the sections from the retractor muscle studied, the spiral form of the nuclei is most abundant where the elastic tissue is most undulating and presumably in the most shortened state.

The microscopic structure, then, of the anterior three-fifths of this muscle is quite characteristically that of any smooth muscle, with, however, a considerable interlacing with yellow elastic tissue. In the posterior portion of the muscle, the histology is quite different (figs. 1 and 3). Interspersed with the typical bundles of smooth muscle cells are frequent small fasciculi of striated muscle fibers. These fasciculi are often broken up with the individual fibers diverging somewhat from the original plane. In other places, a few single and isolated cross-striated fibers are found in the midst of dense smooth muscle fasciculi. In general, however, the grouping of the striated fibers is in small fasciculi, alternating with equally small bundles of the non-striated variety. This rather general arrangement can be made out in a low-power photomicrograph of a characteristic field in the posterior two-fifths of the muscle (fig. 3). In this, it is seen that the general direction of the fasciculi is parallel to the long axis of the muscle.

Under higher magnification, the cross-striated fibers are found to possess the typical structure of such voluntary muscles from other parts of the body. The striation (fig. 4) is very distinct and outspoken, very regular and at right angles to the long axis of the fiber. The alternation of light and dark bands is entirely similar to that of typical cross-striated muscle. The nuclei, oval and with only a small amount of chromatin, are found solely in the peripheral portions of the fibers. Between these fibers, a minimum amount of white fibrous connective tissue

with but few yellow elastic fibrils is found. When stained by Mallory's method, the cross-striations of these fibers are beautifully brought out, if Kingery's ('16) use of this stain after Bouin's fixation be followed. Under this higher magnification, also, the smooth muscle fibers are found to be quite similar to those of other organs (fig. 4).

In the posterior two-fifths of the retractor muscle, the proportion of striped fibers to the unstriped is about equal, or the unstriped fibers may be somewhat in excess. This proportion has been calculated from a study of the serial sections through the whole retractor muscle of an adult dog; it represents not an exact determination of the amount of either type of muscle but rather a rough judgment of the proportion. In many single sections, as illustrated by figure 3, the relative amounts of striated and smooth muscle may be easily estimated. Apparently, the amount of striped muscle in the one puppy studied was somewhat less than in the adult animals.

In the gross, it seemed possible that the striated element of the retractor muscle might be derived from direct extensions of the bulbocavernosus fibers which at their insertions attach partly to the sheath of this muscle in its posterior portion. Serial sections, however, of a block made up of the two muscles removed intact failed to demonstrate any such origin; there was always a definite fibrous sheath interposed between the fibers of the retractor and those of the bulbocavernosus. While no definite continuous prolongation of the striated fibers from the adjacent structures was demonstrated, it is possible that they are derived from the same anlage as the sphincter ani muscle with which the retractor is so closely associated. The exact origin of the retractor penis muscle is rather indefinite, for the fibers arise gradually out of the sphincter.

The nerve supply to the retractor penis muscle was not demonstrated. It was suggested that if the muscle was supplied by the sacral autonemics (as seems most likely), one might possibly be able to find nerve ganglia either in the muscle or in its sheath. Systematic search was made in serial sections for nerve-cells but with negative results as regards the demonstration of such collections of nerve-cells.

Thus it seems quite necessary to consider this retractor penis muscle as being mixed, composed of both smooth and striated fibers. Until 1915, however, this muscle, so far as it is possible to determine from the literature, was considered as a typical smooth muscle. This conception of its histology has led to its use by chemists as a relatively large mass of smooth muscle tissue, and determinations of the creatin, carnosine and other nitrogenous extractives in it have been made. The finding of a disproportionate amount of these chemical bodies in this muscle differentiated it chemically from other smooth muscles. The chemists, however, have considered that the findings harmonize with Botazzi's observation that the muscle is different physiologically from intestinal or other smooth muscle, for it has a shorter latent period and sometimes presents two types of contraction, viz., the clonic and tonic. But it seems proper to suggest here that the finding of a somewhat larger amount of creatin and other nitrogenous bodies in the retractor muscle was due to the presence of cross-striated fibers.

Retterer and his co-workers ('09-'15), in a series of articles dealing with the structure of muscle, has described the retractor muscle anatomically, both from a gross and microscopical standpoint, and has reviewed the literature on the subject. Chauveau was apparently the first to examine the muscle histologically, and in 1857 described it in the horse as composed of smooth muscle fibers (*fibres musculaires de la vie organique*). Comparative anatomists in subsequent publications either did not comment on the microscopic structure of the muscle or merely stated that it was involuntary. Retterer ('15) concluded that the muscle was striated but attributed the striations to the branching of the elastic tissue fibers and not to the characteristic cross-striations of voluntary muscle. These branches were described as leaving the longitudinal elastic fibers at right angles and encircling the muscle fibers or even passing into their substance, so as to give the appearance of heart muscle. Such appearances have also been observed in the present study, but the phenomenon of the cross branching of elastic fibers was found to occur only in the smooth portion

of the muscle. It must be emphasized, however, that these lateral branchings of the elastic elements of the muscle are entirely different from the striations of the striated fibers in the posterior part of the muscle where the cross-striations observed are evidently due to the alternation of light and dark bands in the myofibrils, as in typical cross-striated muscle fibers.

Botazzi ('15), who made an extensive study of the retractor muscle from a physiological standpoint, divided the muscle into three parts—an anterior or prepucial end, a middle portion, and a posterior or perineal end. He stated that the posterior fraction is darker than the other portions and suggested that it resembles striated muscle in its gross appearance. On direct stimulation he obtained from some specimens two types of contraction—a clonic or twitch contraction, and a tonic contraction (slow and gradual)—while from other preparations he obtained only the tonic contraction. He writes (page 11) that “if the animal is very large the muscle is excessively long and then I take only the prepucial and middle parts. If instead the animal is small, I isolate and take out also the extreme perineal end.” While he does not state with which muscle preparations he obtained the two types of contraction, it is possible that they were obtained only from those preparations comprising the entire muscle. This would include the portion of the muscle containing the striated fibers which on direct stimulation should give a clonic type of contraction. On the other hand, the smooth muscle fibers might well be expected to yield only the tonic type of contraction.

It seems, then, justifiable to conclude that the retractor penis muscle of the dog is mixed. In the anterior three-fifths the fibers are wholly smooth while in the posterior two-fifths the fibers are both smooth and cross-striated. The divergent chemical and physiological observations based on the assumption that this muscle was wholly smooth, have a possible explanation in the mixture of the two kinds of muscle fibers here described.

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PLATE 1

EXPLANATION OF FIGURES

1 Retouched photomicrograph of typical field in anterior two-fifths of the retractor penis muscle of the dog. The smooth muscle fibers are shown collected in bands and converging somewhat at the anterior termination of the muscle. Enlargement, 240 diameters.

2 Retouched photomicrograph, under higher magnification, of the rectangular area shown in figure 1. The fasciculi of smooth muscle fibers are shown separated by somewhat abundant connective tissue. The nuclei of the non-striated fibers exhibit a spiral form. Enlargement, 750 diameters.

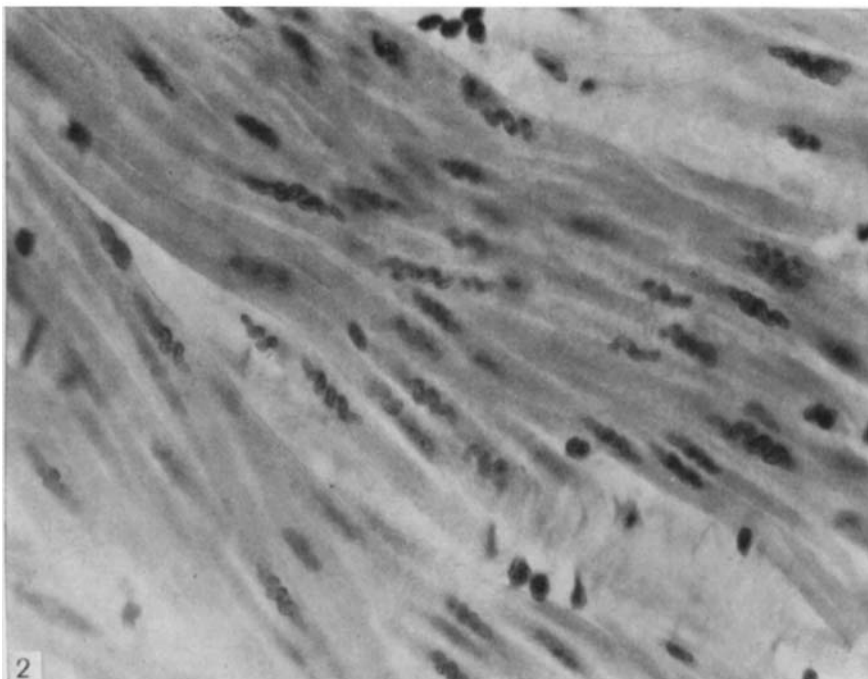
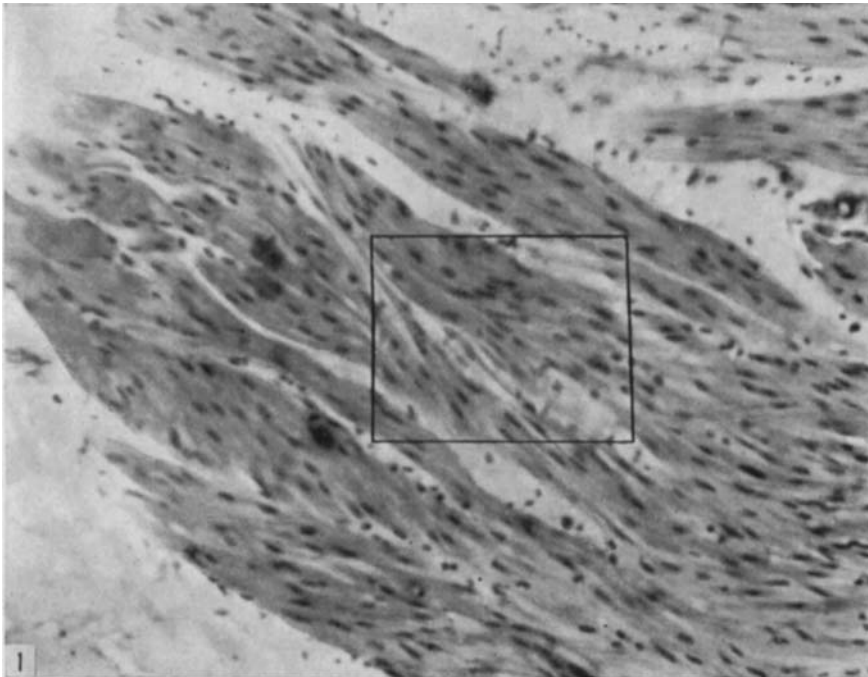


PLATE 2

EXPLANATION OF FIGURES

3 Retouched photomicrograph of a typical field in the posterior two-fifths of the retractor penis muscle of the dog. The alternation in the section of striated and non-striated fibers is well brought out and the equal proportion of the two types of fibers is indicated. Enlargement, 180 diameters.

4 Retouched photomicrograph of the squared area in figure 3. The typical cross striations of the cross-striated muscle fibers and the peripheral distribution of their nuclei is well brought out. On both sides of these striated fibers are dense bundles of smooth muscle. Enlargement, 750 diameters.

