

## The Morphological Study of the Muscle Spindle in the EDL Muscle from Three Normal Pigs

Akiteru Takagi Ph.D.\*, Motohiro Kimura(Top Manager)\*\*, Etsuko Suzaki Ph.D.\*\*\*, Ryuji Nomura Ph.D.\*\*\*\*, Katsuko Kataoka Ph.D.\*\*\*

Keywords: Types of Muscle spindle, distribution of muscle spindle, branches of EDL muscle spindle, pig and mouse, sectioning.

### Introduction

At the latest Congress of ISEK in Sapporo, Japan, we demonstrated that there are three types of muscle spindles in the *extensor digitorum longus* (EDL) muscle, and suggested that several types of distribution patterns of the muscle spindles were present in the mouse EDL muscle.

The EDL muscle of the pig is separated into three tendoned fibers, while that of the mouse is composed of four fibers. In this study, we specifically examined muscle spindles in the middle branches of the EDL muscle from three pigs.

### Materials and Methods

Six pieces of the middle branch of the EDL muscle from three normal pigs (6 months old, male) were used in this study. An example of the

pig EDL muscle and its three branches are shown in Fig. 1, with those of the mouse for comparison. The average weight and length of the six pieces were  $13.6 \pm 3.1$  g and  $93.7 \pm 14.0$  mm respectively.

Isolation of muscle spindles from the middle branches of the EDL muscles was performed using two of the six pieces. Each sample was fixed in 10% buffered formalin and cut into 15 parts under a stereo-microscope as shown in Fig. 2. Muscle spindles were isolated from each part and photographed. The longitudinal length, the length of the equatorial region and the maximum diameter of the equatorial region of each spindle were measured. The muscle spindles were classified into three groups by longitudinal length. The ratios of the maximum diameter to the whole longi-

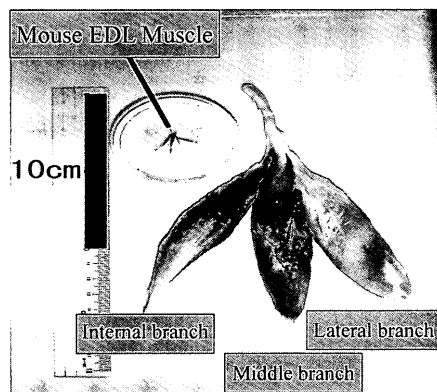


Fig. 1 comparison of the Pig EDL and mouse EDL muscle.

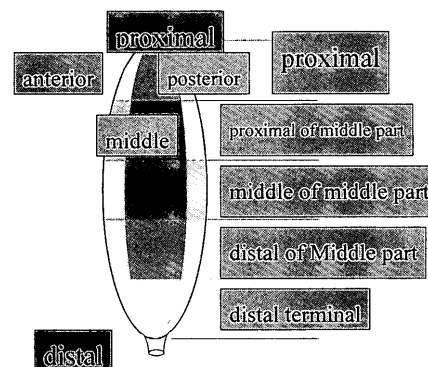


Fig. 2 15 sections of the middle branch of the EDL muscle.

\*Department of Physical Therapy, School of Health Sciences, Niigata University of Health and Welfare

\*\*Department of Rehabilitation, Koyo Newtown Hospital

\*\*\* Department of Histology and Cell Biology, Graduate School of Biomedical Sciences, Hiroshima University

\*\*\*\*Department of Anatomy I, Fujita Health University School of Medicine

tudinal length were compared by between the 3 groups Mann-Whitney test ( $p < 0.05$ ).

The other four middle branches of the EDL muscle were prepared for serial horizontal sections. After fixation in 10% buffered formalin, the middle branches were mounted in agar and cut into a series of 200  $\mu$ m-thick sections at 3-4 mm intervals by a microslicer (DTK-1500, D. S. K.). Spindles in those sections were examined by a stereo-microscopy.

**Results**

Seventy-four muscle spindles were isolated from the two pieces of the middle branch. The spindles were classified into three groups by longitudinal length, namely, standard, long and short types (Fig. 3). Table 1 shows the numbers of isolated muscle spindles found within each group.

**1. Standard type**

**2. Long type**

**3. Short type**



**Fig. 3 Three types of the muscle spindle.**

	46 pieces (62%)	22 (30)	6 (8)
length	$3.64 \pm 0.79$ mm	$6.02 \pm 0.93$	$2.20 \pm 0.27$
equatorial region length	$1.04 \pm 0.20$ mm	$1.29 \pm 0.15$	$0.48 \pm 0.10$
maximum diameter	$0.29 \pm 0.06$ mm	$0.32 \pm 0.07$	$0.16 \pm 0.01$

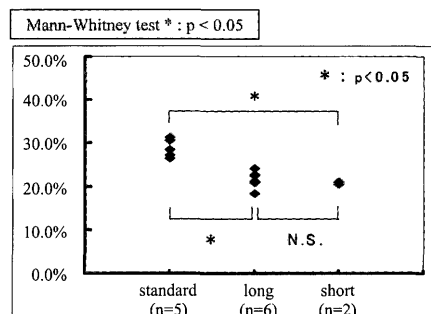
**Table 1 Size of muscle spindles.**

Table 2 shows the ratio of the maximum diameter to the whole longitudinal length. The ratios of the three types were compared by Mann-Whitney test ( $p < 0.05$ ).

One hundred and two pieces of muscle spindles were found in the serial sections from four middle branches of the EDL muscles. In total, 176 spindles were found from six pieces of the middle branch. Table 3 and Fig. 4 show the distribution of 176 muscle spindles found from six middle branches of the EDL muscles.

**Discussion**

Three types of muscle spindles were found in the pig EDL muscle. This is similar to those in the mouse EDL muscle<sup>1)</sup>. The percentage of each type in the pig was nearly equal to that in the mouse (Table 4: comparison between the present



**Table 2 The ratio between maximum diameter of equatorial versus whole longitudinal length.**

total	Anterio	midfd	posteri	Standar	Long	Short
26	3	17	6	11pieces	5	0
proximal terminal						
72	9	59	4	19	4	6
proximal of middle part						
48	5	33	10	12	4	0
middle of middle part						
23	4	15	4	4	5	0
distal of middle part						
7	2	3	2	0	4	0
distal terminal						
176	23	127	26	46	22	6

**Table 3 Distribution of muscle spindles in the middle branch of EDL muscle**

Observation of serial sections → 102 of muscle spindles were found.

Isolation of muscle spindles → 74 were found.

In total 175 muscle spindles were found fro 6 pieces of the middle branches.

above : numbers of muscle spindles

below : percentage Types of muscle spindles

mouse	standard	long	short
%	58%	36	6

pig	standard	long	short
%	62%	30	8

**Table 4 The ratio of the three types between the mouse and the pig.**

and our previous studies<sup>1)</sup>. It is further suggested that the mammal may have morphologically different types of muscle spindles in the EDL muscle.

The distribution of muscle spindles in the pig EDL muscle is such that about 70 % of the spindles were found in the proximal portion of the middle part of the middle branch. Give the both proximal and distal tendons terminate in the proximal of the middle part of the middle branch; it is reasonable to assume that muscle spindles are located more densely in the region most sensitive to the tension of muscles (Table 3 and Fig.

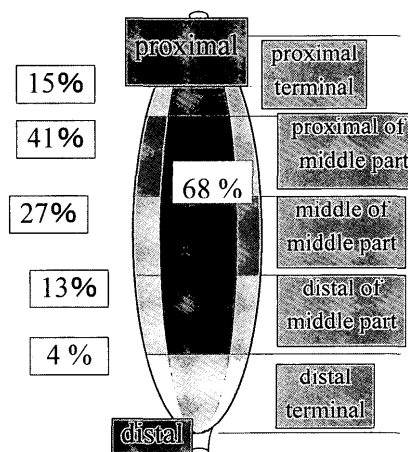
4). Among the three types, the standard type was most common. Many of the standard type appeared in proximal portion of the middle part of the middle branch, which would be the most sensitive region to changes in length and tension of the muscles. Therefore of the this types, it may be the standard type that plays the most important role in the stretch reflex. The long type was evenly distributed throughout all regions of the middle branch. This type may be less sensitive, and baou the function of detecting more grass ouerall changes in laught and tension of the muscle. Conversely, the short type was rare, making it difficult to suggest their function at the present.

Further electrophysiological studies will be needed to verify the individual function of the three types of muscle spindles.<sup>2)3)4)5)</sup>

**Conclusion**

Three conclusions can be drawn from the present study.

1. Three types of muscle spindles were found in the middle branch of the pig EDL muscle, as we had previously demonstrated in the mouse<sup>1)</sup>.
2. The distribution of muscle spindles was not even in the middle branch of the EDL muscle.



**Fig. 4 Distribution of muscle spindles in the middle of the EDL muscle.**

3. Each type of muscle spindles showed a different distribution, and will probably have different roles.

#### References

- 1) Takagi A., Matsutani S., Suzaki S., Kataoka K. ( Niigata Journal of Health and Welfare, 1:47-52. 2001.
- 2) Barker D; In: Handbook of Sensory Physiology, III/2 CC Hunt (ed), p85, Springer-Verlag, Heidelberg, 1974.
- 3) Hartung V, et al: Mechanoreceptors; Development, Structure, and Function, P Hnik, et al (eds), p89, Plenum, New York, 1988.
- 4) Bank RW, et al: Mechanoreceptors; Development, Structure, and Function, P Hnik, et al (eds), p263, Plenum, New York, 1988.
- 5) Stepons H, et al: In: Mechanoreceptors, Development, Structure, and Function, P Hnik, et al (eds), p271, Plenum, New York, 1988.