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## A cytological study on the effect of nerve crush injuries in striated muscle fibers

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## Abstract

The changes in muscle fibers after the crush injuries of the nerve were studied with rat sciatic nerve, and the following results were obtained. 1. After a severe crushing, the tendency of grouping of a single muscle fiber type was observed, although this scarcely occurred after slight injuries. 2. The muscle function and structure recovered better after crush injuries of the nerve than after the nerve reunification.

## A CYTOLOGICAL STUDY ON THE EFFECT OF NERVE CRUSH INJURIES IN STRIATED MUSCLE FIBERS

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In the previous paper (1), the changes of striated muscle fibers after the nerve reunification and cross-innervation were reported. In this study the changes in both structure and fiber types of muscle fibers after the crush injuries of the rat sciatic nerve are described in detail.

### MATERIALS AND METHODS

Under anaesthesia by the intraperitoneal injection of sodium pentobarbital, the sciatic nerves of adult Wistar rats were exposed. The right sciatic nerve for the length of 10mm was vigorously crushed with hemostat, and the left one slightly for about 3mm long. Rats were killed 3, 4, 6, 9, 13, 15, 19 and 24 weeks after the operation. M. extensor digitorum longus (EDL) was mainly examined with Sudan black B staining as described in the previous paper (1). Before killing, the function of hind limbs was checked. The function of EDL was easily observed by the degree of extension of II, III, VI, V toes.

### RESULTS

Three weeks after slight crushing, the toes were completely paralyzed. The Sudan sections of EDL revealed a decrease in both fiber diameter and content of mitochondria. Most fibers showed the area lacking in mitochondria (Fig. 5).

Six weeks after the vigorous crushing, EDL still remained practically paralyzed. In Sudan sections it was noticed an increase in mitochondria; namely, a sign of regeneration in some fibers, although in others an area lacking in mitochondria still remained (Fig. 6). In the slightly crushed side, the recovery of function as well as regeneration of muscle fibers was more advanced (Fig. 2).

From 9 to 13 weeks after slight crushing, the function of EDL recovered practically to the normal level. From 15 to 20 weeks after the strong crushing, the functions of EDL and the leg returned to almost the

normal level. In this instance, the structure of most muscle fibers seemed to give normal appearance (Fig. 7). The distinct feature was the grouping of single fiber type as observed in the nerve reunification experiment (1) (Figs. 3 and 4). However, after, the slight crushing, the grouping of single fiber type could scarcely be detected.

Twenty-four weeks after the severe crushing; namely, after crushing the sciatic nerve vigorously for the length of 10mm several times with hemostats, the function of the leg being not normal, complete extension of the toes was not obtained. In such instance, histological pictures of the EDL showed single fiber type grouping very prominently (Fig. 8).

#### DISCUSSION

Through this study, a parallel relationship was observed between the muscle function and histological findings of Sudan sections of muscle fibers. In paralyzed stage, muscle fibers were in denervation atrophy; namely, the fiber diameter and the number of mitochondria were diminished. On the sign of functional recovery, the number of mitochondria increased. As the function returned to almost normal, the fiber structure also resumed practically a normal appearance.

In this experiment, it has been demonstrated that the muscle function and muscle fiber distribution recover almost completely after slight crush damages. However, in the case of severe crush injuries, the grouping of single fiber type appears following the reunification of the nerve (1). Probably, in such instances, most of nerve fibers are severed and the major part of muscle fibers falls into denervation atrophy. Then the reinnervation from the branch of the single nerve to atrophied muscle cells and differentiation to the same type of fibers occur as in the reunification experiment (1).

In comparing the present result with the nerve reunification experiment (1), generally, even after the severe crushing, the motor function recovers better than that after the reunification of the nerve. The tendency of fiber type grouping is less prominent in the former than in the latter. These results suggest that on the nerve crush injury, generally, it would be better to preserve the crushed part of the nerve than to cut off and to reunify it.

#### SUMMARY

The changes in muscle fibers after the crush injuries of the nerve were studied with rat sciatic nerve, and the following results were obtained.

1. After a severe crushing, the tendency of grouping of a single muscle fiber type was observed, although this scarcely occurred after slight injuries.

2. The muscle function and structure recovered better after crush injuries of the nerve than after the nerve reunification.

#### REFERENCES

1. OGATA, T. SEITO, T. and HINO, H.: A cytological study on the effect of reinnervation and cross-innervation in rat striated muscle. *Acta Med. Okayama*, in press.

#### EXPLANATION OF FIGURES

All pictures show the extensor digitorum longus muscle (EDL) of the rat, stained with Sudan black B.

Fig. 1 Normal EDL, illustrating three types of muscle fibers.  $\times 400$

Fig. 2 Six weeks after a slight nerve crushing. Note the appearance of the structure of muscle fiber is practically normal. Fiber type grouping is not observable.  $\times 100$

Fig. 3 Twenty-four weeks after severe crushing. Note the grouping of red fibers.  $\times 100$

Fig. 4 Other part of the same specimen as in Fig. 3, showing the grouping of fiber types.  $\times 100$

Fig. 5 Three weeks after a slight crushing. Note the areas of lack of mitochondria in muscle fibers.  $\times 400$

Fig. 6 Six weeks after a slight crushing. Note most fibers are in the regeneration stage and the number of mitochondria is increased. Even the white fiber has a rim of mitochondria. Some fibers still reveal the area lacking in mitochondria.  $\times 400$

Fig. 7 Fifteen weeks after the slight crushing. The muscle fibers present almost normal appearance  $\times 400$

Fig. 8 Twenty weeks after the severe crushing. Note the grouping of red fibers and very small fibers in regeneration period.  $\times 400$

