SENSORY FIBER REGENERATION AFTER DORSAL ROOT GANGLION SECTION IN RATS

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By using model experiments on animals it is possible to solve some applied and theoretical problems concerning the study of mechanisms of repair processes in the nervous system after spinal cord injury. In publications on regeneration of damaged dorsal root ganglion (DRG) fibers [3, 6-9] the ability and rate of regeneration of peripheral and central axons of sensory neurons were studied after injury to the dorsal root and spinal nerve [8], and the response of bodies of sensory neurons to injury to their processes [2, 10]. However, the separate study of the regenerative capacity of peripheral [5] and central DRG fibers [9], the varied character of the experimental injury (division and compression), and also the use of different species of animals for the experiments, make a comparative evaluation of the results difficult. Besides, the ability of fibers to grow after their division immediately next to the body of the sensory neuron has remained completely unstudied. In this investigation we used hemitransection of the DRG and the technique of axonal iontophoresis of cobalt salts (AICS) on a preparation of DRG in vitro. By this method it is possible to monitor regeneration of peripheral and central fibers of ganglion cells simultaneously, in order to study their morphology and the dynamics of their regeneration during growth through a scar.

EXPERIMENTAL METHOD

Hemitransection of the left DRG was carried out at level T13 under pentobarbital anesthesia (40 mg/kg) in 30 noninbred albino rats, male and female, weighing 100-150 g. The animals were killed with an overdose of pentobarbital 3, 7, 15, 30, 120, and 180 days after the operation. Axonal iontophoresis of cobalt salts was carried out on a DRG preparation in vitro (P. V. Velichenko, 1978) through the ventral branch of the spinal nerve or the dorsal root at the level T13 on the side of the operation. Histologic preparations were photographed, drawn, and analyzed in the "Ortholux" light microscope (Leitz, West Germany). The results of measurement of the fibers under normal and experimental conditions were subjected to statistical analysis.

EXPERIMENTAL RESULTS

By axonal iontophoresis of cobalt, it is possible to stain nerve cells with their processes in histologic preparations, and to differentiate nerve fibers growing through the site of injury clearly (Fig. 1). WE studied general regeneration of central and peripheral nerve fibers through a scar in DRG with similar morphological characteristics and time course. On the 3rd day single thin ($d = 1.5 \pm 0.2$ μ) twisting fibers were observed to be growing into the glial and connective-tissue scar, and to have passed through the scar on the 7th day. These fibers had growth bulbs in the zone of the scar. According to the diameter of their axon, the regenerating fibers did not differ significantly from those in the intact ganglion ($d = 3.1 \pm 1.2$ μ). on the 15th day the number of growing fibers in the scar increased considerably. The morphology of the fibers from the distal part, growing into the dorsal root, and from the proximal part, growing into the spinal nerve, was the same. On the 30th day the number of regenerating fibers was unchanged, but differences appeared in the character of growth of the fibers from the distal and proximal parts of DRG: some fibers, having grown

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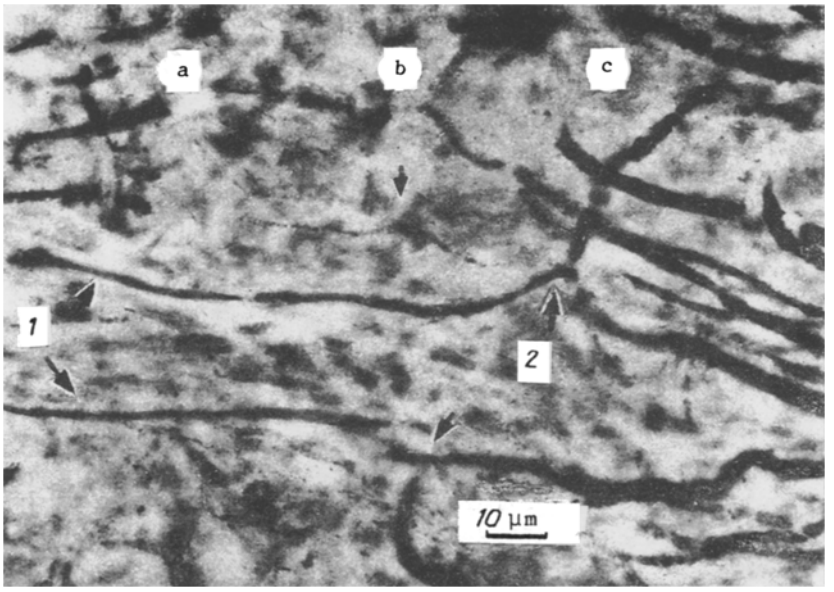

Fig. 1. Zone of scar in DRG (30 days after division): a) proximal part, b) scar, c) distal part. 1) Central axons of DRG neurons growing through scar; 2) sites of bifurcation of processes of DRG neuron. AICS method.

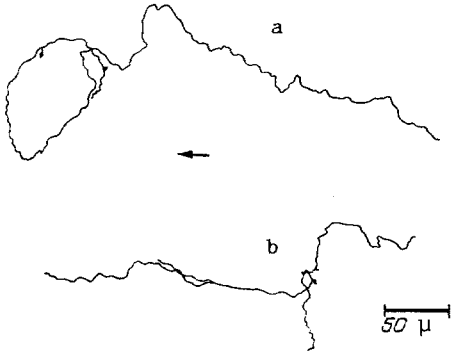

Fig. 2. Accurate drawings of regenerating fibers of DRG neurons: a) nerve fiber growing from distal into proximal part of ganglion and interweaving around neuron body, to form bud-like outgrowths on it; b) nerve fiber growing from proxima; part into distal. Arrow indicates direction of growth of fiber. AICS method.

through the connective-tissue scar from the distal part, interwove around neurons in the proximal part (Fig. 2) and formed bud-like outgrowths on the body of these cells. It can be tentatively suggested that by means of these processes, the fibers make contact with the cell body. In the later stages the morphological picture of fiber regeneration in the scar was unchanged. By the 120th and 180th days there was only a very small increase in the number of growing fibers and in their growth into the dorsal root and spinal nerve, from the distal and proximal parts of DRG respectively.

Thus on the 15th day the divided central processes of DRG neurons were growing into the dorsal root, and those from the periphery into the spinal nerve. We showed that central and peripheral processes of DRG neurons were equally capable of growing through the scar. Our results are in agreement with those obtained in injury to the dorsal roots and sciatic nerve [3, 7], where regeneration began on the 3rd-7th days. The closeness of the line of section to the body of the sensory neurons in the present experiments clearly did not delay the beginning of regeneration of the neuron processes and had no significant effect on their ability to cross the glial and connective-tissue scar. It is not always the case that the farther from the neuron body its processes are divided, the more rapidly they are repaired [4]

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