Transplantation of Pacinian Corpuscles of the Rat into the Brain

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Summary. In adult inbred rats of the AVN strain, branches of the crural interosseous nerve were dissected out from donors and transplanted into the brain of recipients, together with a cluster of Pacinian corpuscles, (either into a suction cavity or the cerebral cortex) into a slit 1 - 2 mm deep. The grafts were fixed and processed for electron microscopy 10 days to 6 months after the operation, and their ultrastructure was examined. Sporadic axons of small diameter grew into the nerve branches of some of the grafts from 11 days onward, and became myelinated during the 2nd month after the operation, but none of the transplanted Pacinian corpuscles became reinnervated. The corpuscles, however, survived denervation and grafting. Most of them retained a well-preserved inner core and an intact capsule, consisting of a normal complement of $29.2 \pm 1.0$ (mean ± SE) capsular layers ($n = 8$), as did the corpuscles previously examined after denervation in situ. Some of the corpuscles underwent degenerative changes, presumably due to a delayed or restricted revascularization. In this group of corpuscles, the inner core underwent disintegration and was gradually replaced by collagen fibrils, whereas the capsule remained preserved but the number of its layers eventually reduced by 40%. It is assumed that the lack of reinnervation of the grafted Pacinian corpuscles was due to the paucity of regenerating central axons, and their failure to form correct projections along those Schwann cell columns connected with the corpuscles.

Key words: Pacinian corpuscles — Transplantation to the brain — Electron microscopy

Introduction

Transplants of peripheral nerves have been used to bridge over lesions in the brain and spinal cord, since regenerating central axons can grow through a peripheral nerve along the Schwann cell columns and thus reach the predilected target area (Kao et al. 1979; Horvat 1980, 1983; Richardson et al. 1980, 1982; Weinberg and Raine 1980; Aguayo et al. 1984). The question has remained open, however, whether central axons growing into a peripheral nerve can also reinnervate peripheral end-organs, if these are transplanted together with the nerve. Encapsulated sensory receptor organs appear to be suitable for transplantation. Glees et al. (1949) transplanted individual Pacinian corpuscles — mechanoreceptors responsive to vibrations (Hunt 1974) — from the mesentery to the brain of adult cats, and reported that the structure of these corpuscles remained preserved for a year after grafting, although no reinnervation had occurred. We have modified the approach of Glees et al. (1949), using for transplantation a branch of the crural interosseous nerve of rat with a cluster of Pacinian corpuscles attached to it, in an attempt to promote axonal regeneration. The nerve with corpuscles was dissected out from adult donor rats and grafted into the cortex or a suction cavity in the brain of host rats. The ultrastructure of the grafts was examined from 10 days to 6 months after the operation.

Material and Methods

Inbred adult albino rats (150 g) of the AVN strain were used in this study. The operations were carried out under general pentobarbitual (Nembutal) anaesthesia and sterilized instruments and solutions were used.

In the anaesthetized donor rats, the posterior tibial muscle was removed from the hind limb together with the crural interosseous nerve and Pacinian corpuscles that are localized on the muscle surface. A piece of the nerve, with approximately five corpuscles attached, was dissected out under the microscope and used for transplantation.

The head of the recipient anaesthetized rat was fixed, shaved and washed with 70% ethanol. Then the cranium was exposed and the periosteum removed. The bone of the transplantation site was removed by a stomatologic drill; the innermost part of the bone was removed by forceps. A small incision was made in
the dura and Pacinian corpuscles were grafted in the parietal superficial cortex into a slit 1–2 mm deep. In one instance, the graft was placed into a surgically prepared suction cavity between septum and hippocampus, transecting the fornix and the hippocampal fimbria (Stenevi and Björklund 1981).

At designated time intervals from 10 days up to 6 months after the transplantation, the anaesthetized animals were perfused intracardially with a fixative composed of 1% paraformaldehyde and 1% glutaraldehyde dissolved in 0.12 M phosphate buffer (pH 7.3). After approximately 2 h, brains were removed and further fixed in a fresh fixative overnight. Then blocks of tissue were excised from the transplantation site, postfixed in a 2% solution of osmium tetroxide, dehydrated and embedded in Durcupan ACM, Fluka, Switzerland. In all, grafts from 17 rats were examined by light and electron microscopy. On semithin sections stained with toluidine blue, the regions containing Pacinian corpuscles were selected for ultrathin sectioning. Ultrathin sections were cut on a Reichert OMU 3 ultramicrotome and viewed, after staining with uranyl acetate and lead citrate, in a JEM 100B electron microscope.

Results

Localization of the Transplants

The grafted Pacinian corpuscles could be easily recognized in semithin sections, because their capsules were conspicuous and inner cores remained more or less preserved (Figs. 1, 2). In the cortical grafts, the corpuscles were either entirely embedded in the brain tissue, or protruded to a varying extent above the surface of the brain. The corpuscles grafted into the intraparenchymal cavity adhered to its glia-covered wall on one side; the rest of the transplant protruded into the lumen. In the transplants, nerve branches could be discerned as round or oval profiles delimited by the perineurium (Fig. 1), which had retained its characteristic lamellar layers.

Reinnervation of the Grafted Nerves

In the nerve branches within the transplant, original axons degenerated after transection and their debris was taken up and resorbed by Schwann cells. Two weeks after the operation, resorption of axonal debris was virtually completed, and Schwann cells proliferated, forming columns inside the old basal laminae (Fig. 3). Regenerating axons, the origin of which was not verified, grew into the nerve and appeared in some of the endoneurial tubes among the Schwann cell processes. The number of axons growing into the transplant was small, and not more than one or two axonal profiles, of less than 0.5 μm diameter, were found in a basal-lamina tube (Fig. 3). All basal laminae were infolded, as they only contained a small number of slender Schwann cell processes and occasional axons; in some instances a single Schwann cell process accompanying an axon was observed within a richly infolded basal-lamina tube (Fig. 4). Two months after the operation, a reinnervated nerve was found in the central area of the transplant (Fig. 5). It contained a number of myelinated axons 1–2 μm in diameter, with myelin sheath about 0.3 μm thick, and a few axons that remained unmyelinated. None of the axons, however, reached the grafted corpuscles. Since the number of regenerating axons was small, no attempt was made to determine their origin.

Ultrastructure of Transplanted Corpuscles

All Pacinian corpuscles examined in our study remained devoid of innervation. They could be divided into two groups according to their degree of structural preservation. In the first group were Pacinian corpuscles with a well-preserved inner core and capsule (Figs. 6, 7). Only the sensory terminal had degenerated...