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Plastic Capacity of Growing and Regenerating Myelin Sheaths

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According to the generally accepted theory of Betty Geren, the myelin sheath develops as an elongation of the glial plasma membrane. Data about an incorporation of membranous material from the glial cytoplasm to the outer and inner mesaxons have been presented in the literature. In this study, developing and regenerating peripheral nerves were investigated by conventional electron microscopy. We have shown another group of membranes of the sheath, which are able to incorporate cytoplasm components. From the inner or outer surface of the compact myelin disintegrate segments of the lamellae, which acquire the morphological and cytochemical characteristics of the myelin-forming membranes. The disintegration of segments from the "rigged" compact myelin, that increases the possibility of the myelin sheaths to develop and regenerate, indicates their significant plastic capacity.

Key words: nerve fibers, myelin sheath, postnatal development, regeneration, plasticity.

Introduction

1971 Webster [8] has established that the myelin lamellae grow exponential quickly than the glial plasmalemma, the source of the myelin sheath [5]. The non-compact membranes of the myelin sheath (mesaxons, paranodal and Schmidt-Lanterman lamellae) were proposed to be sites for incorporation of glial cytoplasm material to the growing sheath [2, 7, 9]. In the present study, we demonstrate additional membranes, dynamic disintegrated segments of the compact myelin, which we believe to belong to the myelin-forming membranes. The segments, likely the myelin-forming membranes, are strongly positive for the myelin-associated enzymes (5`-nucleotidase and Na+, K+-ATPase), moderately positive towards ruthenium red and cationized ferritin, and negative towards lectins [9].

Material and Methods

Group A. Rabbits of 8 age groups (newborn — 4 months) were used. Segments of ventral and dorsal spinal roots were removed and investigated. Group B. Tibial nerves of adult rabbits were cut and restored by primary grafting. Segments 1 cm

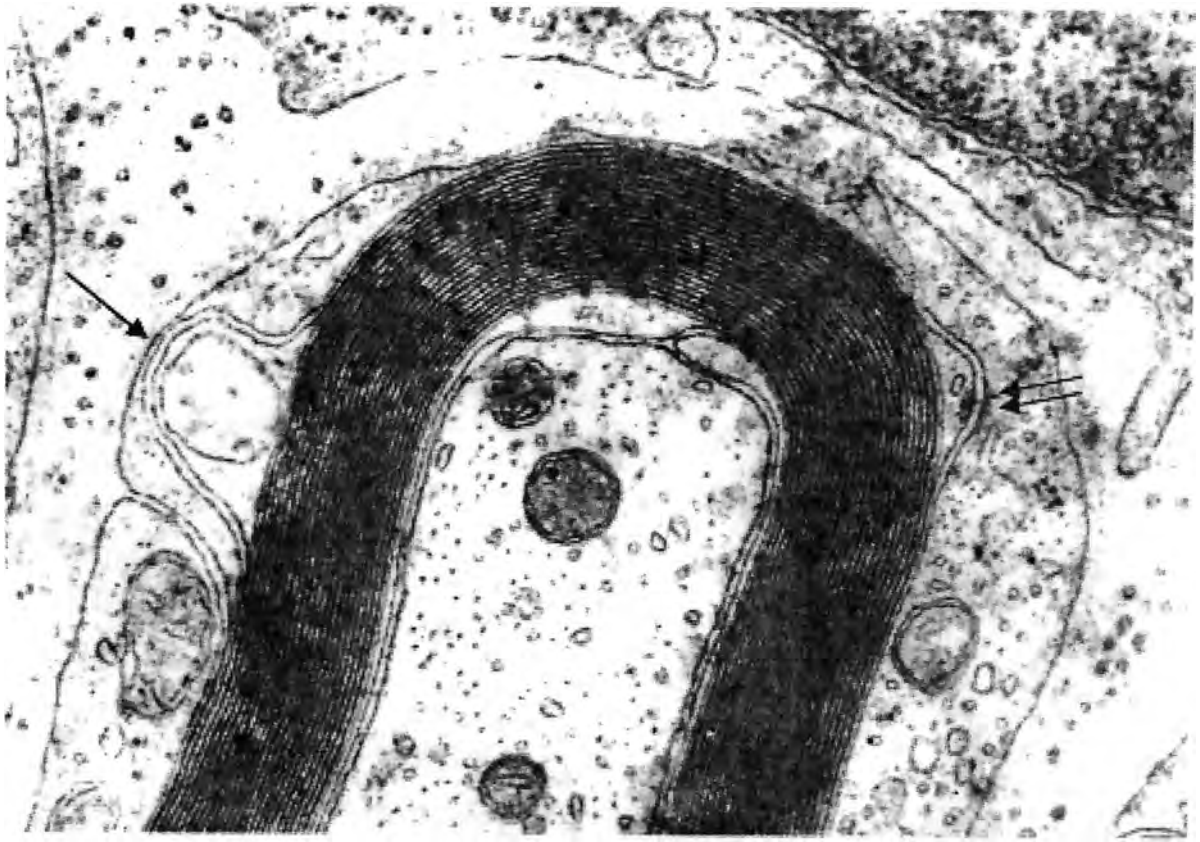

Fig. 1. 15-day-old rabbit. A transversal section through radix anterior. A disintegrated peripheral segment near the outer mesaxon (arrow). The split segment at the opposite side of the myelin sheath in association with desmosome-like structure (double arrow). EM Siemens I × 60 000

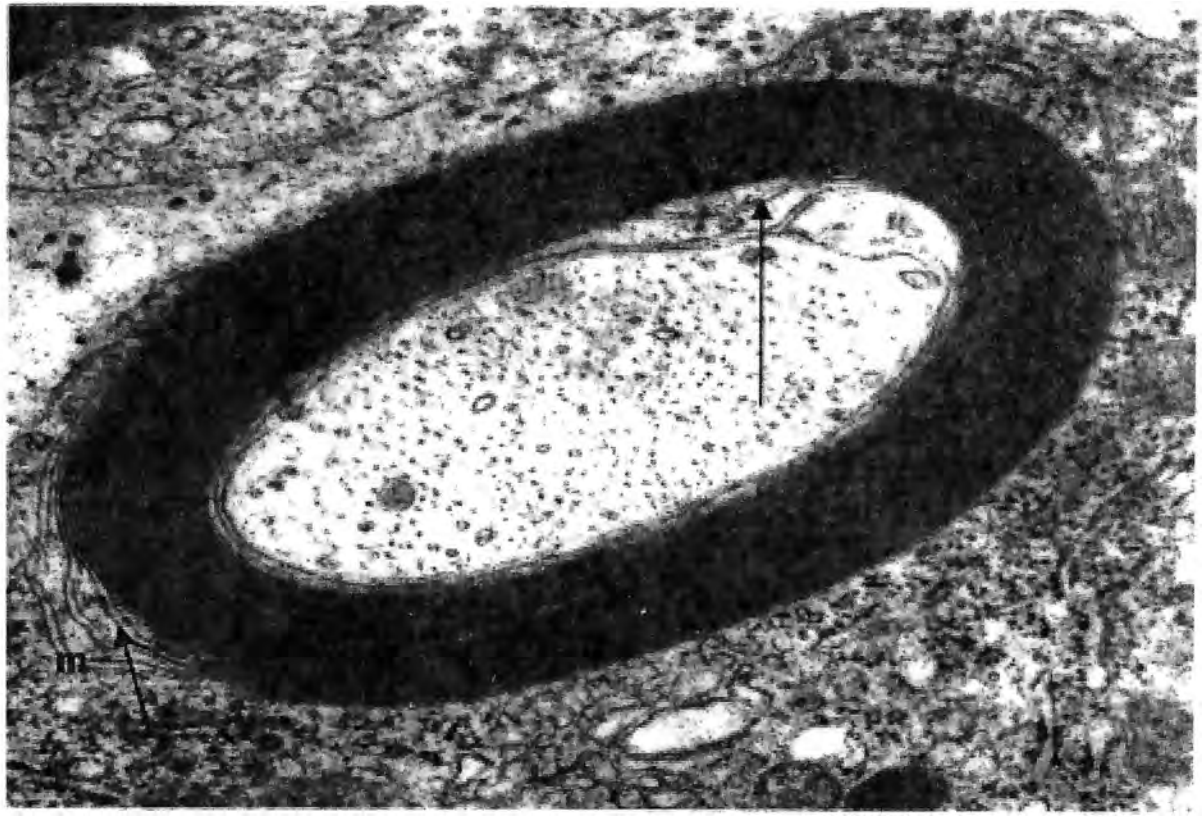

Fig. 2. 15-day-old rabbit. A transversal section through radix anterior. A disintegrated segment from the inner surface of the myelin sheath (long arrow). Two segments disintegrated from the outer surface of the sheath near the outer mesaxon m (short arrow). EM Siemens I (× 60 000)

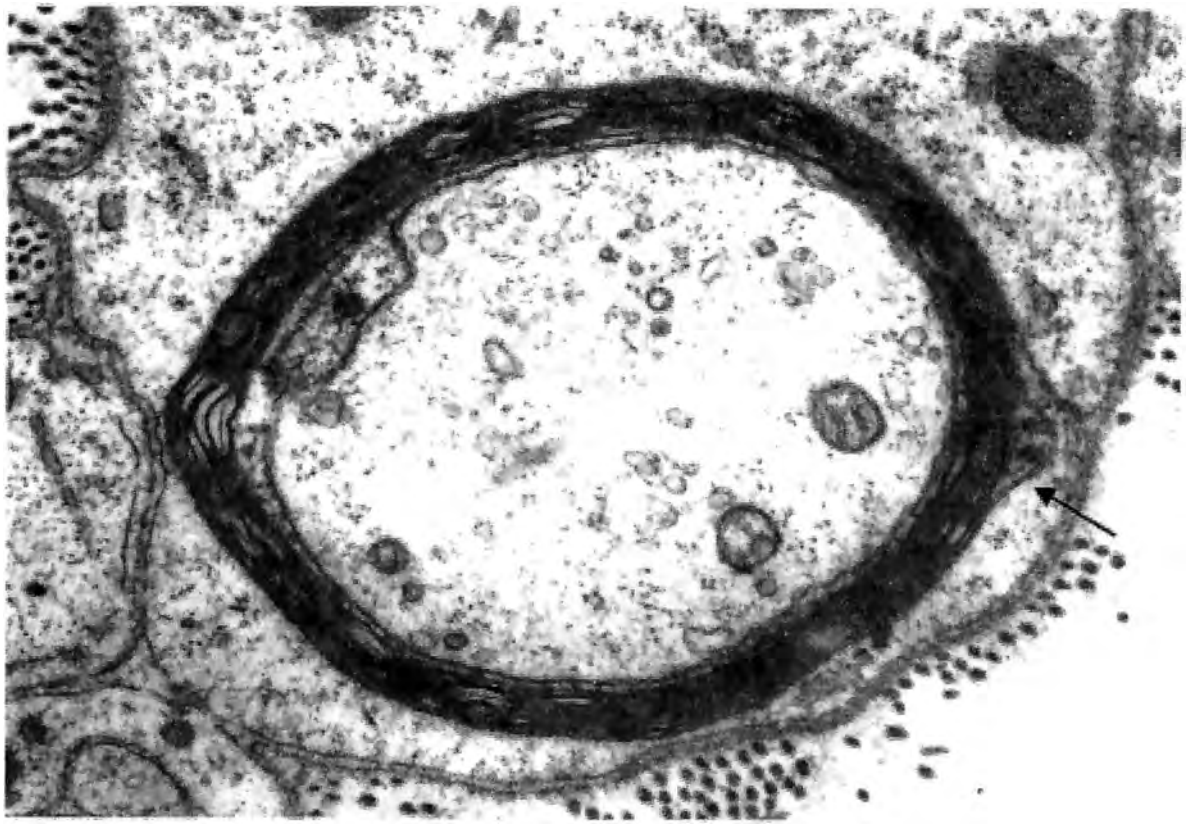

Fig. 3. A transversal section through regenerating n. tibialis 30 days after primary grafting, 1cm distal to the graft. A disintegrated segment from the outer surface of the myelin sheath near the mesaxon (arrow). EM Hitachi H500 (× 32 000)

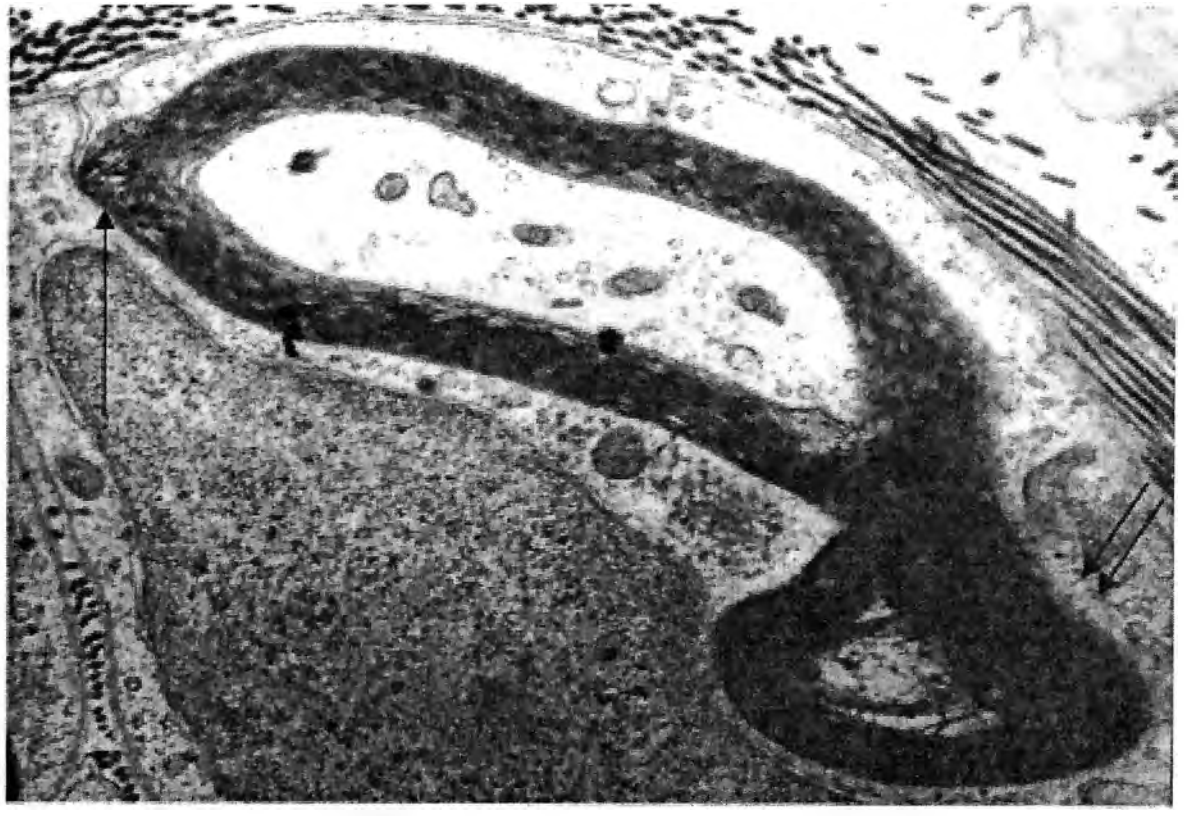

Fig. 4. A transversal section through regenerating n. tibialis 28 days after primary grafting, 1cm distal to the graft. Disintegrated myelin lamellae near the outer mesaxon (arrow). Overproduced myelin (double arrow). EM Hitachi H500 (× 23 000)

distal to the graft were removed 28, 30 and 40 days after grafting. The material from both investigated groups of animals was prepared for EM according to the routine protocol. Transversal sections were examined under SiemensI and Hitachi H500 EM.

Results

In developing and mature myelinated nerve fibers, we have quite frequently seen disintegrated segments from the compact myelin. More frequently appeared split peripheral myelin lamellae, near the outer mesaxon or at the opposite side of the myelin sheath (Fig. 1). More rarely appeared inner disintegrated myelin lamellae, as a rule near the inner mesaxon (Fig. 2). Desmosome-like structures were often associated with the split segments (Fig. 1). In Fig. 2 could be seen developing desmosome-like structures between the outer mesaxon and the next two split myelin segments. In regenerating myelin sheaths, the disintegrated segments have shown similar dispositions (Figs. 3, 4). During the regeneration, we have frequently observed an overproduced myelin (Fig. 4).

In all cases, close interrelations were seen between the split myelin segments and membranous profiles of the Schwann cell cytoplasm (Figs. 1-4).

Discussion

The dynamic disintegration of inner and outer lamellae was observed in the animals of all investigated age groups, in regenerating myelinated nerve fibers, in growing and mature myelin sheaths. We believed that these split lamellae are sites of incorporation of glial cytoplasm material to the growing myelin sheaths, such as the mesaxons [2, 9]. In adult animals, the myelin sheath is considered to renew constantly [7]. The desmosome-like structures of the disintegrated myelin lamellae might take part in the mechanism of incorporation of cytoplasm profiles to the myelin sheaths. The cytochemical characteristics of the structures [3, 4, 9] show, that they are more similar to the gap junctions, accelerating repeatedly the metabolic exchange between the territorial units connected by them [1]. We suppose that the overproduced myelin (Fig. 4) called "aberrant" myelin [6] results from an intensive incorporation of cytoplasm material to the disintegrated lamellae. We can see similar images in the transversally cut paranodal areas. In the present case, however, the section of the myelinated fiber contains the nucleus of the Schwann cell, indicating the middle part of the internode. We have observed aberrant myelin significantly frequently in the regenerating nerve fibers than in the growing fibers.

References

1. Balice-Gordon, R. J., L. J. Bone, S. S. Scherer. Functional gap junctions in the Schwann cell myelin sheath. — J. Cell Biol., **142**, 1998, 1095-1104.
2. Bunge, R. P., M. B. Bunge, B. Bates. Movements of the Schwann cell nucleus implicate progression of the inner (axon-related) Schwann cell process during myelination. — J. Cell Biol., **109**, 1989, 273-284.
3. Fannon, A. M. et al. Novel E-cadherin-mediated adhesion in peripheral nerve: Schwann cell architecture is stabilized by autotypic adherens junctions. — J. Cell Biol., **129**, 1995, 189-202.
4. Fujimoto, K. et al. Distribution of anionic sites on intracellular organelles: A study by labelling frozen thin-section with cationized ferritin. — Acta Histochem. Cytochem., **18**, 1985, 455-463.

5. G e r e n, B. B. The formation from the Schwann cell surface of myelin in peripheral nerves of chick embryos. — Exp. Cell Res., 7, 1954, 558-562.
6. P e r e y r a, P. M., P. E. B r a u n. Studies on fractions, which are involved in myelin assembly: Isolation from developing mouse brain, and characterization by enzyme markers, electron microscopy, and electrophoresis. — J. Neurochem., **41**, 1983, 957-973.
7. S a m o r a j s k i, T., R. L. F r i e d e. A quantitative electron microscopic study of myelination in the pyramidal tract of rat. — J. Comp. Neurol., **134**, 1968, 323-338.
8. W e b s t e r, H. de F. The geometry of peripheral myelin sheaths during their formation and growth in rat sciatic nerves. — J. Cell Biol., **48**, 1971, 348-367.
9. Д о л а п ч и е в а, С. Аксон-миелин-Швановоклетъчният комплекс в развитие и експеримент. Дисерт. труд, София, 2001.