The Bilateral Effect of Unilateral Nerve Injury - ^{2}H DQF NMR Study of Rat Sciatic Nerves

H. Shinar[1], Y. Seo[2], Y. Morita[3], K. Ikoma[3], G. Navon[1]

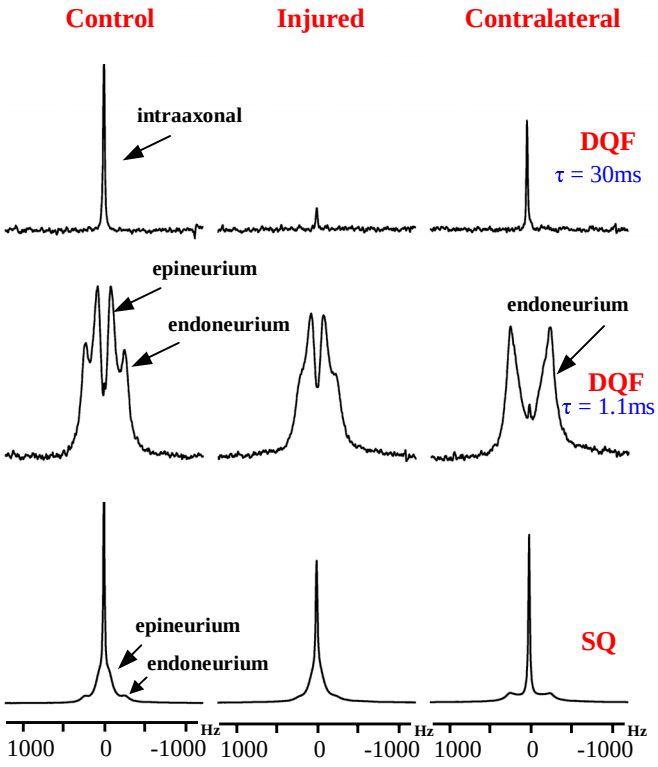
[1]School of Chemistry, Tel Aviv University, Tel Aviv, Israel, [2]Dept. of Regulatory Phsiology, Dokkyo University School of Medicine, Tochigi, Japan, [3]Dept. of Orthopaedic Surgery, Kyoto Prefectural University of Medicine, Kyoto, Japan

Introduction: There are sporadic reports in the literature [1-3] that unilateral injury of a peripheral nerve has an effect on the contralateral nerve. This effect, which is hitherto unexplained and remained questionable in the medical community, has major clinical implications and, from the research point of view, rules out the contralateral nerve as a valid control. Here we present a ^{2}H DQF NMR study of the effect of Wallerian degeneration on the three nerve compartments of the injured, contrallateral and the control rat sciatic nerves. Striking differences between the contrallateral and the control nerves are reported.

Materials and Methods: The right sciatic nerve of Wistar rats was injured and both the injured and the contralateral nerves were isolated 1, 2, 3, and 4 days after the incision (n=3 for each time point). The isolated nerves were equilibrated in deuterated saline and positioned in 5 mm NMR tubes containing Fluorinert with their long axis parallel B_0. ^{2}H in-phase DQF spectra, at various creation times (τ) [4] and SQ spectra were measured on a Bruker ARX 500 NMR spectrometer.

Theoretical Background: The quadrupolar splitting ν_Q depends on the ^{2}H quadrupolar splitting ν_b of water molecules directly interacting with the fibers, their fraction P_b, and the alignment relative to the magnetic field according to: $\nu_Q = \nu_b P_b (3\cos^2\theta - 1)/2$. The ^{2}H NMR spectrum of rat sciatic nerve equilibrated in D_2O consists of a strong singlet accompanied by two pairs of quadrupolar split satellites [5]. The satellites were previously assigned to the water in the epineurium (ν_Q~120 Hz) and the endoneurium (ν_Q~450 Hz). In the double quantum filtered (DQF) spectrum, the strong singlet, which is mainly due to free water, is filtered out and another, relatively narrow signal, which in the single pulse spectrum was masked by the water signal, is evident. This narrow signal (ν_Q~10 Hz) was assigned to intraaxonal water. In the epineurium and endoneurium it was shown that the quadrupolar splitting stems from the interaction of the water molecules with the oriented collagen fibers, while in the axon, it might be the interaction with the neurofilaments.

Results:. During the 4 days of the study, a continuous and significant decrease of the narrow DQF signal assigned to the intraaxonal water was observed. At day 4 (see Fig.), only a very small intraaxonal signal is detected in the injured leg as compared to the contralateral and intact control. The effect on the water of the endoneurium and the epineurium is much less significant, as can be seen both from the SQ and DQF spectra. In the contralateral nerves the intraaxonal signal is only slightly affected. On the other hand we observed a fast and large decrease of the water signal from the epineurium after the incision. At day 4 this signal is almost undetectable.



Discussion: The decrease of the intraaxonal signal is an indication of degeneration of the neurofillaments. In the contralateral nerve, the injury affects mostly the external compartment of the nerve – the epineurium. The method we are using is sensitive to ordering and in the case of the epineurium, we have previously shown that this is determined by the collagen fibers. We can thus deduce that in the contralateral nerve the collagen fibers of the epineurium are severly affected. These results are in accordance with Beel et al. [3]) who has found the contralateral nerves have altered mechanical properties.

References:

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