Introduction

Previous studies have found that peripheral nerves below the neurological level of spinal cord injury (SCI) are subject to functional changes that are mostly attributed to inactivity or pressure palsies in subjects with chronic SCI.1 To date, it is uncertain whether structural changes only occur at a distal level or whether proximal parts of peripheral nerves are also affected. The aim of this study was to combine structural T2-Weighted and functional diffusion weighted (diffusion tensor imaging, DTI) imaging of the sciatic nerve with clinical and electrophysiologic assessments in subjects with chronic SCI.

Methods

20 subjects with chronic SCI (>1 year after injury) and 20 healthy controls matched for age, body mass index, and gender underwent magnetic resonance neurography (MRN) of the right thigh in a 3 Tesla scanner (Magnetom PRISMA, Siemens, Germany). A T2-weighted (T2w) sequence with spectral fat suppression and a DTI sequence were recorded. Segmentation of the sciatic nerve was performed manually. The process of image acquisition and segmentation is illustrated in Figure 1.

Figure 1: MR neurography (MRN) of the sciatic nerve (a) anatomic location of imaging (blue cube), the sciatic nerve is marked with a red ellipse (b) axial T2-weighted (T2w), fat-suppressed MRI sequence at mid-thigh level, the sciatic nerve is marked with a red square (c) magnification of the area marked in (b), T2w-hyperintense fascicular lesions can be seen in the peroneal (Per) and the tibial (Tib) compartment of the sciatic nerve (d) binarized image of T2w-hyperintense nerve lesions (white) in contrast to normal nerve tissue (black)

The amount of T2w-hyperintense fascicular nerve lesions in % of the full nerve volume were calculated via an established approach using ImageJ and MATLAB.2 The sciatic nerve’s fractional anisotropy, a dimensionless quantity obtained from DTI that has been shown to pose a reliable marker for myelin integrity of peripheral nerves in previous studies3, was calculated in a semi-automated approach using the FDA-approved software Nordic BRAINEX. An illustration of T2-weighted and diffusion-weighted sequences in individuals with SCI and controls is provided in Figure 2.

Imaging results were subsequently correlated with electrophysiologic results and clinical data in all participants.

In chronic SCI, the sciatic nerve’s lesion load showed correlations with tibial nerve conduction velocities (NCV; r=0.72; p<0.001, Figure 4a), tibial compound motor action potentials (r=0.50; p=0.041), tibial distal motor latencies (r=0.49; p=0.046), and sural NCV (r=0.51; p=0.038). The sciatic nerve’s fractional anisotropy correlated with tibial NCV (r=0.72; p<0.001, Figure 4b) and tibial compound motor action potentials (r=0.59, p=0.014). For both sciatic nerve lesion load and fractional anisotropy, no correlations were found with the neurological level of injury, the American Spinal Injury Association Impairment Scale (AIS) or the the Lower Extremity Motor Score (LEMS).

Figure 4: Tibial nerve conduction velocities (NCV) and MRN parameters of the sciatic nerve in subjects with chronic SCI (a) lesion load (r=0.72; p<0.001) (b) fractional anisotropy (FA, r=0.72; p<0.001)

Conclusions

This study found that there are correlations between proximally recorded MRI parameters of the sciatic nerve and distally recorded electrophysiologic parameters of the tibial nerve in subjects with chronic SCI. No such correlations could be found between the obtained imaging parameters and scores of SCI severity or cumulative motor strength of the lower extremities. These results are of particular interest with regards to an involvement of the peripheral nervous system (PNS) in chronic SCI. The finding that imaging parameters that were obtained at a very proximal level are correlated with electrophysiologic results obtained distally indicates that pressure palsies, which are usually assumed to occur at the level of the knee or further distally, may not be the sole cause of damage and functional impairment of peripheral nerves following SCI. The finding that peripheral nerve MRI parameters showed no correlation with the level of injury, AIS or LEMS further indicates that PNS changes following SCI are not directly related to SCI severity. Further studies on MRN in SCI are warranted.

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References


Figure 2: examples of MRN results in controls and subjects with SCI (a) T2-weighted (T2w) image of the sciatic nerve in a 32 year old male control participant with regular signal of the tibial (Tib) and peroneal (Per) compartment (b) color coded fractional anisotropy (FA) map of the sciatic nerve in the same position as in (a), obtained from diffusion tensor imaging (DTI) (c) T2w image with large, T2w-hyperintense fascicular lesions of the sciatic nerve’s compartments of a 39 year old male participant with chronic spinal cord injury (AIS A) and severe neuropathic pain below the level of injury

Figure 3: Group comparisons of MRN results (a) Fascicular lesion load of the sciatic nerve (% of nerve volume) in individuals with chronic SCI (8.70±1.747.47) and controls (3.60±2.45; p<0.001) (b) Fractional anisotropy of the sciatic nerve in chronic SCI (0.55±0.11) and controls (0.63±0.08; p=0.022)