Magnetization Transfer (MT) Segmentation of foot peripheral nerves at 3 T.

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Introduction

The ability of tracking peripheral nerves in foot could be of great benefit for a number of clinical and research applications, which include traumas, diabetes and infections. Previous approaches to nerve tracking have employed diffusion tensor imaging (DTI, [1, 2]), which is a well established method of fiber tracking in the central nervous system. In the peripheral nervous system (PNS), however, one limitation of DTI is the low signal-to-noise ratio (SNR) due to short T2 of water protons in nerve [3-5]. Furthermore, in imaging of foot nerves, the low SNR is exacerbated by the need of the high spatial-resolution ($\leq 300\mu m$) required to visualize the small nerves. Here, we propose a novel approach to nerve visualization, which exploits the difference in magnetization transfer ratio (MTR) between muscle and foot nerves.

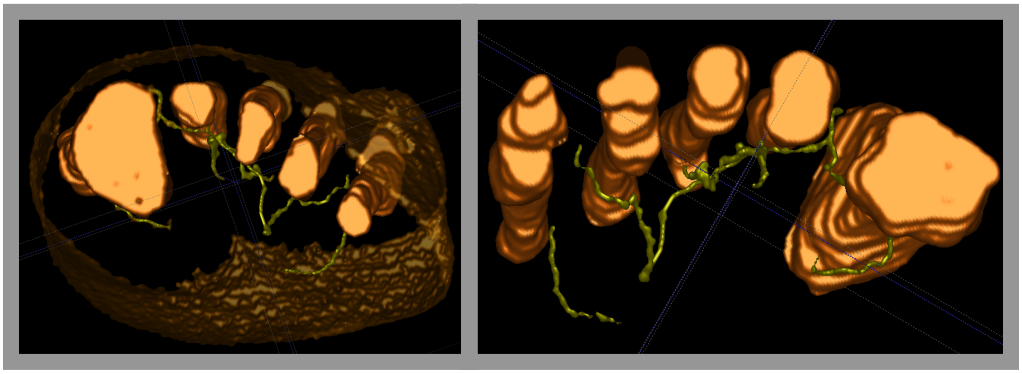

***Fig. 1**. MT segmentation of forefoot interdigital nerves. **Left**: posterior-anterior view. **Right**: Zoom-in, anterior-posterior view. For reference, segmentation of the bones (left and right) and skin (left) was performed as well.*

Methods

MRI experiments were performed on a clinical 3T Tim Trio Siemens scanner (Siemens Medical Solutions, Erlangen, Germany) with a transmitter/receiver circularly-polarized coil. The MTR was measured in the foot nerves of five healthy volunteers. Two sets of spoiled gradient-echo images were acquired, with and without a saturation pulse. MTR was calculated according to the standard equation $MTR = 100*(So - Ss)/So$, with So and Ss being the signal without and with off-resonance saturation pulse, respectively.

Results/Discussion

A significant difference of MTR was observed between foot nerves and adjacent muscles. In particular, the MTR of forefoot interdigital nerves ([22.1±5.9]%, [20.9±4.8] % and [21.9± 4.7]%, first, second and third interdigital nerve, respectively) was significantly lower than the MTR of adjacent muscle ([45.8 ± 3.4]%). The difference in MTR provided a novel source of contrast nerve-foot. Based on the MTR contrast, MT nerve segmentation was feasible. MT tractograms of interdigital foot nerves are shown in **Fig.1**. and **Fig.2**. At the current stage, nerve MT segmentation is occasionally confounded by the neighbouring veins that might display similar values of MTR depending on their blood flow velocity. An additional data acquisition would be required to distinguish veins from nerves in all cases. It should be noted that MTR is sensitive to soft tissue damage, so it can also provide information on nerve damage, in particular on assessment of collagen integrity and demyelination processes. Traumatic injuries or chronic nerve insults like in diabetic disease could potentially benefit of new markers of disease impact, progression and recovery.

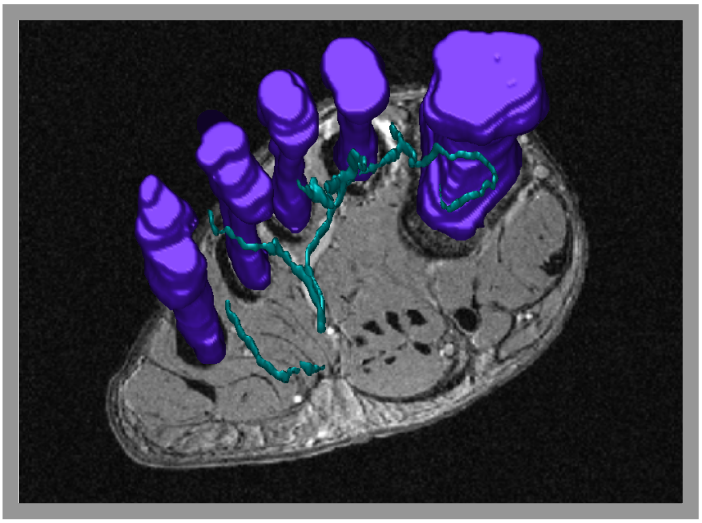

***Fig. 2**. MT segmentation of forefoot interdigital nerves (and bone segmentation) with a reference MRI forefoot axial image.*

Conclusions

MTR provides a means for high spatial-resolution tracking of peripheral foot nerves. This novel approach is directly applicable on standard clinical MR scanners.

References. [1] Skorpil M et al., Magn Reson Imaging. 2007;25:406-11. [2] Hiltunen J et al., Clin Neurophysiol. 2005;116:2315-23. [3] Gambarota G, et al., Muscle Nerve. 2007;36:368-73. [4] Gambarota G, et al., J Magn Reson Imaging. 2009;29:982-6. [5] Gambarota G, Semin Musculoskelet Radiol. 2009;13:24-8.