A fast scanning technique of MR micro-neurography using the 3-Point-Dixon method at 3T

Paolo F Felisaz[1], Eric Y Chang[2], Irene Carne[3], Polesel Marco[1], Stefano Montagna[4], Maugeri Giulia[1], Baldi Maurizia[4], Fabrizio Calliada[1], and Stefano Bastianello[5]
[1]Radiology Department, University of Pavia, Pavia, Italy, [2]Radiology Service, VA San Diego Healthcare System, San Diego, CA, United States, [3]Medical Physics Department, IRCCS Salvatore Maugeri Foundation, Scientific Institute of Pavia, Italy, [4]Radiology Department, IRCCS Salvatore Maugeri Foundation, Scientific Institute of Pavia, Italy, [5]Department of Brain and Behavioral Sciences, University of Pavia, Pavia, Italy

Target audience: People interested in high-resolution MR neurography with a fast scanning protocol and the 3-point-Dixon method.

INTRODUCTION

MR micro-neurography is a non-invasive technique that provides visualization of the microanatomy of peripheral nerves, otherwise available only with histopathology. Small size and complex anatomy of nerves are the main limitations to MRI, thus high field scanners and small diameter coils are typically needed. Fast 3D imaging based on spoiled gradient echo sequences provides a combination of high spatial resolution and adequate SNR[1]. The 3-point-Dixon technique[2] is time saving, because it provides fluid and fat sensitive images from a single scan sequence. The objective of this study is to present a fast clinical MR protocol for micro-neurography based on IDEAL (Iterative Decomposition of water/fat using Echo Asymmetry and Least-squares estimation - GE Healthcare, USA) using a 3T MRI scanner and a readily available coil, optimized for clinical peripheral nerve evaluation.

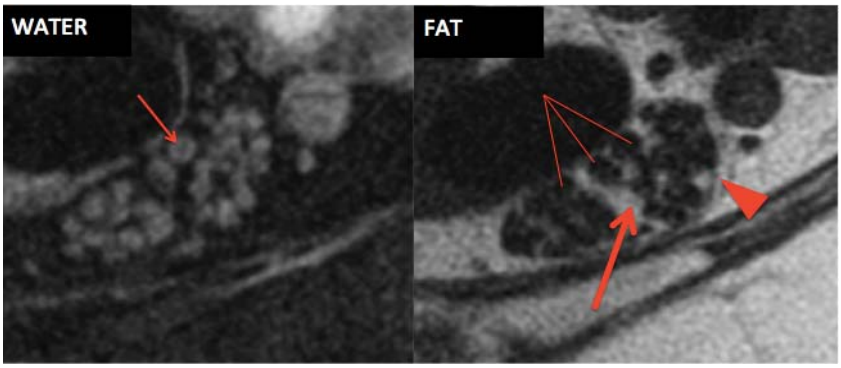

Fig. 1. SPGR IDEAL, WATER and FAT images of the posterior tibial nerve at the ankle in axial plane. Fascicles are seen in groups (straight lines), composed of myelinated and unmyelinated nerve fibers, interspersed in a connective stroma, the endoneurium. These are sorrounded by the perineurium a multi-layer membrane rich in collagen, seen with high signal in the "water" image (small arrow). Fascicles are held together in the epineurium, a fibrous connective tissue containing a variable amount of fat (big arrow). The outermost connective layer is the paraneural fascia (arrowhead).

MATERIALS AND METHODS

Imaging was performed on five healthy volunteers, two patients with diabetes-related neuropathy, two with amyloid-related neuropathy and three with tarsal tunnel syndrome. Scans were focused on the posterior tibial nerves at the level of the medial malleolus. Imaging was performed on a Discovery MR750 3T scanner (GE Healthcare, USA) using a 6-Channel Carotid Array Coil adapted for the ankle. 3D SPGR with IDEAL was used with TR 14 ms, TE 8 ms, flip angle 10º, matrix size 512 x 420 FOV 5 cm, slice thickness 2 mm for total proximal-distal coverage of 2 cm, bandwidth 35 kHz, NEX 1 and total time of scan of approximately 6 min. 3D with chemical fat suppression were also usedwith otherwise similar parameters (4 NEX, time of scan 10-12 min) and axial 2D TSE T1-w with TR 650ms, TE 25ms, ETL 5, Matrix size 512 x 512, FOV 5 cm, slice thickness 2 mm with 0.5 mm gap, bandwidth 30 kHz, NEX 6, and total time of scan of approximately 8-10 min.

RESULTS

Microscopic tissues within the nerve, such as the paraneural fascia, the epineurial fat, the fibrous epineurium and even the perineurium that covers the fascicles were visualized (Figures 1 and 2) using the above protocols. SPGR with IDEAL provided water and fluid sensitive images in a single scan, with similar level of details in respect of the SPGR with standard fat suppression and the TSE T1-w. Qualitative differences were readily appreciated between healthy volunteers and patients with neuropathy of various clinical degrees (Fig. 2).

DISCUSSION

Peripheral nerves have anatomical traits that are advantageous for MR microscopy imaging. First they are anisotropic in shape, allowing larger slice thickness to be used (i.e. 2-3 mm) as long as they are imaged in the short-axis (axial plane) with high in-plane resolution (i.e. 100-120 µm) without appreciable quality reduction due to partial volume effects. Second, peripheral nerves are frequently superficial and readily imaged with small surface coils. With MR micro-neurography microscopic nerve components can be visualized in routine clinical practice. Fast 3D SPGR sequences with IDEAL provides robust and consistent fluid-fat separation in a single acquisition. MR micro-neurography may complement standard MR neurography protocols, in particular for focused evaluation of a selected nerve.

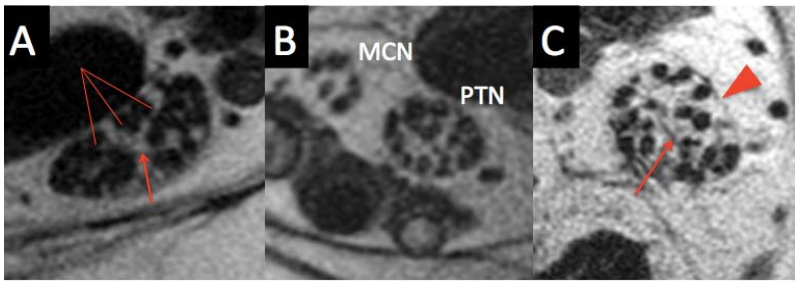

Fig. 2. 2D TSE T1-weighted with approximately 100 µm resolution. Posterior tibial nerves at the ankle from different patients.[A] Suspected tarsal tunnel syndrome with mild neuropathy.[B] Mild diabetic neuropathy. [C] Severe amyloid related neuropathy. The fascicles (straight lines) are interspersed with a variable amount of epineurial fat, seen bright. Fibrous epineurium (long arrow) and paraneural fascia (arrowhead) are also seen, with low signal. Note the separation of the medial calcaneal nerve (MCN) branch of the posterior tibial nerve (PTN).

REFERENCES

1. Bydder, G.M., et al., *MR Imaging of Peripheral Nerves with Short and Ultrashort Echo Pulse Sequences.* Presented at ISMRM, Salt Lake City, Utah, 20-26 April 2013.**2**. Dixon WT. Radiology. 1984.153(1):189-94.