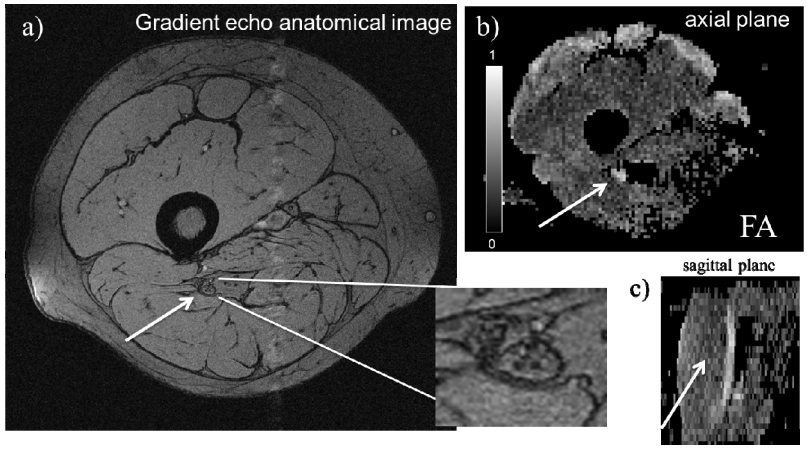
Diffusion tensor measurements in healthy human sciatic nerve

Christopher DJ Sinclair[1,2], Laura Mancini[2,3], and John S Thornton[1,2]

[1]MRC Centre for Neuromuscular Diseases, UCL Institute of Neurology, London, London, United Kingdom, [2]Department of Brain Repair and Rehabilitation, UCL Institute of Neurology, London, London, United Kingdom, [3]Lysholm Department of Neuroradiology, National Hospital for Neurology and Neurosurgery, London, London, United Kingdom

Introduction The sciatic nerve runs from its roots in the lumbar-sacral plexus to a few centimetres above the knee joint and conveys the motor and sensory signals in the lower limbs. Sciatic nerve abnormalities include focal tumours and changes in a range of peripheral neuropathies including chronic inflammatory demyelinating polyneuropathy (CIDP) and the various types of Charcot-Marie-Tooth disease (CMT). The sciatic nerve lies deep within the thigh musculature, making it relatively inaccessible to electrophysiological or surgical investigation. In contrast, MRI offers direct visualization and quantitation of nerve properties that may be valuable in diagnosis and monitoring disease progression and response to new therapies. However, unambiguous identification of the sciatic nerve against the confounding background of blood vessels and other features can be difficult, and quantitative MRI in such a relatively small structure presents challenges in terms of spatial resolution and SNR. We investigated sciatic nerve fractional anisotropy (FA) obtained in healthy volunteers by diffusion tensor imaging (DTI) as a contrast source to identify the nerve course. As an initial assessment of the feasibility of obtaining quantitative diagnostic or disease progression markers by sciatic nerve DTI, we report normative FA and mean diffusivity (MD) values.

Methods The right thighs of 5 healthy subjects (4 male) aged 33.0±6.4 (mean±s.d.) years were imaged at 3T (Siemens TIM Trio) in the feet-first supine position with a Tx-Rx 'CP extremity' coil . To visualise the structure and location of the sciatic nerve, a high-resolution 2D gradient echo acquisition was used (TR/TE=575/9ms, 1024x1024matrix 280x184mm field of view (FOV), 35x3mm contiguous slices, flip angle=45°, bandwidth (BW)=230 Hz/pixel). DTI acquisitions comprised a spin-echo EPI readout (TR/TE=6600/78ms, 128x128matrix, 220x192.5mm FOV, 49x6mm contiguous axial slices, 5/8 partial Fourier phase encoding, BW=1562 Hz/pixel) with gradient reversal fat-suppression [1] available in the Siemens 511E works in progress package. Two diffusion weightings (b=0, 1000 s/mm^2) and 6 independent diffusion-gradient directions were used to acquire data with 10 signal averages in an acquisition time of 7m49s. The data were processed offline with FSL (FMRIB, Oxford, UK) to calculate the principal diffusion tensor eigenvalues $\lambda_{1,2,3}$ and maps of FA and MD. Regions of interest (ROIs) were drawn on the FA maps enclosing the central component of the sciatic nerve, and in the medial quadriceps muscle. Mean and standard deviation (s.d.) values were extracted for each ROI.



Results A high resolution image depicting the position of the sciatic nerve from a single subject is shown in Figure 1a with an adjacent enlargement of the nerve. Axial and sagittal FA maps are shown in Figure 1b) and c) respectively. White arrows point to the sciatic nerve. The table summarises the derived DTI metrics in the nerve and, for comparison medial quadriceps muscle ROIs across all subjects.

Subject		λ_1 x10^{-3} mm^2/s	λ_2 x10^{-3} mm^2/s	λ_3 x10^{-3} mm^2/s	MD x10^{-3} mm^2/s	FA
1	Sciatic	2.60 ± 0.33	1.15 ± 0.12	0.84 ± 0.22	1.53 ± 0.21	0.55 ± 0.04
	Muscle	1.91 ± 0.14	1.47 ± 0.09	1.28 ± 0.08	1.55 ± 0.04	0.21 ± 0.06
2	Sciatic	2.59 ± 0.08	0.96 ± 0.15	0.72 ± 0.08	1.42 ± 0.08	0.62 ± 0.04
	Muscle	1.97 ± 0.14	1.48 ± 0.11	1.21 ± 0.12	1.55 ± 0.07	0.25 ± 0.05
3	Sciatic	2.52 ± 0.39	0.99 ± 0.27	0.65 ± 0.22	1.39 ± 0.26	0.62 ± 0.08
	Muscle	2.14 ± 0.36	1.77 ± 0.33	1.44 ± 0.33	1.78 ± 0.32	0.20 ± 0.07
4	Sciatic	2.89 ± 0.15	0.96 ± 0.29	0.76 ± 0.18	1.54 ± 0.19	0.65 ± 0.08
	Muscle	1.98 ± 0.19	1.58 ± 0.15	1.23 ± 0.16	1.60 ± 0.11	0.24 ± 0.07
5	Sciatic	2.70 ± 0.38	0.91 ± 0.19	0.72 ± 0.20	1.45 ± 0.25	0.65 ± 0.05
	Muscle	2.03 ± 0.20	1.64 ± 0.16	1.32 ± 0.12	1.66 ± 0.11	0.22 ± 0.06
Mean	**Sciatic**	**2.66 ± 0.15**	**1.00 ± 0.09**	**0.74 ± 0.07**	**1.46 ± 0.07**	**0.62 ± 0.04**
	Muscle	**2.00 ± 0.09**	**1.59 ± 0.12**	**1.30 ± 0.09**	**1.63 ± 0.10**	**0.22 ± 0.02**

Discussion The sciatic nerve was well depicted in the high resolution gradient echo images and was highly conspicuous as a region of elevated FA in axial and sagittal projections (Figure 1). The mean FA of the sciatic nerve was 0.62±0.04, significantly higher than the surrounding muscle FA, 0.22±0.02 (p=<0.01, t-test). There was a small MD difference between sciatic nerve and muscle (p=0.02). Consistent with previous measurements in other peripheral nerves [2], MD does not provide good distinction from blood vessels. FA offers a suitable DTI contrast for unambiguously visualising the course of the sciatic nerve through the thigh. Previous studies have demonstrated reduced FA in the tibial nerves of patients with CIDP [3]. It will be of critical interest to determine if and how quantitatively measured sciatic nerve FA values vary in pathologies causing demyelination of the sciatic nerve sheath or axonal loss which are characteristics of variants of neuropathies such as CMT and CIDP, or help identify focal pathologies.

References [1] Park et al. MRM, 4, p526 (1987) [2] Zhou et al. JMRI, 36, p920 (2012), [3] Kakuda et al. Neuroradiology, 53, p955 (2011)