Magic Angle effect: a relevant artifact in MR Neurography at 3T?

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Background and Purpose:

MR Neurography (MRN) is an emerging diagnostic method for disorders of peripheral nerves (PN). Nerve lesions can be diagnosed by their hyperintensity compared to normal nerve tissue. The “Magic Angle Effect” (MA) is an artifact and can also contribute to a hyperintensity, because it is associated with a T2 increase in tissues densely composed of collagen (maximum T2 at 55° with respect to magnetic field). This effect was first observed in tendons and ligaments. However, it is unclear if the influence of the MA on intraneural T2 is severe enough to provoke false positive findings.

Materials and Methods:

25 healthy subjects underwent MRN of the sciatic nerve at the proximal thigh at 3T. The apparent intraneural T2 relaxation time (T2app) was calculated from a dual-echo turbo-spin-echo sequence (TR = 3000 ms, TE1 = 12 ms, TE2 = 69ms) at seven angles of the sciatic nerve relative to B0: 0°, 30°, 35°, 40°, 45°, 50°, 55°. Precise angle adjustments were accomplished with a dedicated in-bore positioning-aid. Qualitative evaluation of intraneural T2-weighted contrast between the group of healthy subjects and 14 patients with neuropathic lesions was done by comparing contrast-to-noise ratios (CNR) of a turbo-inversion-recovery-magnitude sequence (TIRM; TR = 5000 ms, TE = 76 ms, TI = 180 ms).

Results:

In healthy subjects, the prolongation of T2app from 0° to 55° was from 74.5±13.4 ms to 104.0±16.9 ms ($p<0.001$). The increase in T2app relative to baseline (0°) is shown in Fig.1. Intraneural CNR increased by 1.98±0.69 at 40° and 2.93±0.46 at 55°. Nevertheless, compared to patients with nerves aligned with the magnetic field, the mean CNR of healthy subjects was substantially lower even at the position of maximum MA (55°: 20.6±5.11 vs. 52.6±7.12, $p<0.0001$, cf Fig. 2).

Conclusion:

Our study contributes to settle the controversy if the MA in peripheral nerves is a relevant diagnostic artifact in MR Neurography suggesting that the potential of this artifact for false positive findings is low. This can be concluded because first of all, alignment of peripheral nerves at < 30° relative to B_0 avoids a substantial MA effect. Peripheral nerves except for the nerval plexus of the extremities are usually aligned well enough with B_0, that is at < 30°. Secondly, neuropathic lesions exhibit a clearly stronger T2-weighted signal even if contrasted against artificially T2-weighted hyperintense healthy nerves with the maximum MA at 55°.

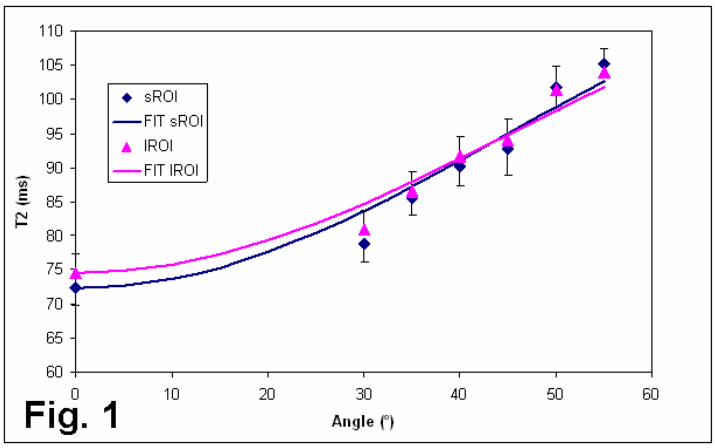

Figure 1. Intraneural variations of the T2app time constant at all measured angulations Θ and the calculated theoretical course. Note that there is a marked increase in T2app when increasing the angle from Θ=30° to Θ=55°.

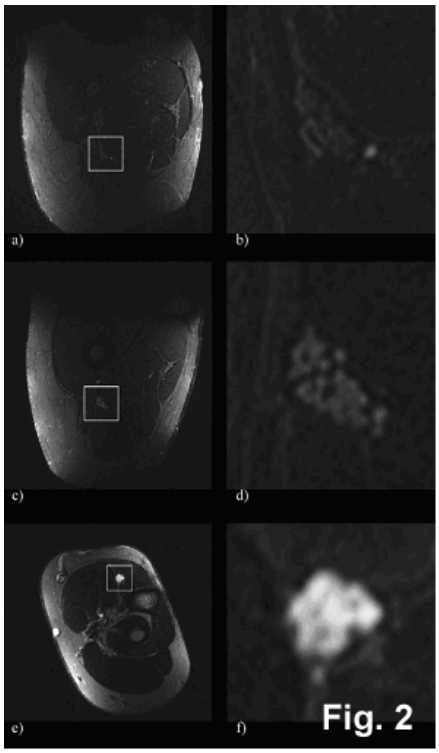

Figure 2. Sciatic nerve of one healthy subject at 0° (a, b) and at 55° relative to B_0 (c,d) and one representative neuropathic lesion at 0°. Transversal T2-weighted TIRM images (left column: a,c,e) are displayed and corresponding zoomed views focusing on the nerve (right column: b,d,f).