

Assessment of Magnetization Transfer Ratio, Diffusion Weighted Image, and T2-Weighted Image in Human Median Nerve at 3T: Comparison with Carpal Tunnel Syndrome

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Introduction: With advances in both software (optimal coil and sequences) and hardware high-resolution MR imaging of peripheral nerves will become more common clinically, paving the way for an expanded role in diagnosis. Moreover, MRI allows not only visualization but also quantitative assessment of intrinsic MR properties such as magnetization transfer ratio (MTR), apparent diffusion coefficient (ADC), and fractional anisotropy (FA) which may correlate with clinical symptoms. Several authors have identified swelling of the median nerve and increased signal intensity on T2-weighted images as important indicators of carpal tunnel syndrome (CTS), however flattening of the median nerve is more controversial [1, 2]. An accurate, non-invasive imaging test which could diagnose CTS would be a significant improvement in clinical care. The aims of this study were to assess normative values for median nerve MTR, ADC, FA, cross sectional area (CSA), flatness ratio (FR), and signal-to-noise ratio (SNR), and to compare them with those of a patient with proven CTS.

Materials: Experiment - 18 volunteers without wrist pain (8 men, 10 women; 21-49 years, mean 31.1) and one patient with CTS were imaged on a 3.0-T GE Twin Speed MRI scanner, HDx 14.0 (General Electric Healthcare, Waukesha, WI, USA) using a transmit/receive quadrature birdcage wrist coil (Mayo Clinic Health Solutions, Rochester, MN, USA). Fast spin-echo T2-weighted spin-echo with fat suppression (FS-FSET2), three-dimensional spoiled gradient-echo (3D-SPGR) with and without MT pulse, and diffusion weighted image (DWI) were acquired. The scan parameters for the FS-FSET2 sequence were as follows: TR/TE 3984/45, +31.25 kHz bandwidth, 2.0mm slice thickness, slice gap 1.0 mm, 25 axial slices, 320 × 256 matrix, echo train length 12, 2 NEX, 10 cm FOV, and scan time 2 mm 42 seconds. Scan parameters for 3D-SPGR was as follows: TR/TE 36 /14 ms, +31.25 kHz bandwidth, 1 mm slice thickness, 75 axial slices, 256 × 160 matrix, 1 NEX, 14 cm FOV, and scan time 8 minutes 9 seconds. Magnitude of MT pulse was 1200 Hz frequency offset, flip angle 670, and duration of 9928 microsecond. Scan parameters for DWI was as follows: TR/TE 6650 /82 ms, +31.25 kHz bandwidth, 4 mm slice thickness, 18 axial slices, 128 × 128 matrix, 3 NEX, 14 cm FOV, B value of 1,000 mm²/sec, and scan time 8 minutes 52 seconds. 1st level SAR limitations were used.

Image Evaluation - The CSA, FR, and SNR were calculated using FS-FSET2 (Fig. 1A). 3D-SPGR with and without MT pulse were transferred to a workstation (Advantage Windows 4.4, GEHC, Waukesha, WI) to calculate MTR map. The MTR, ADC, and FA value were calculated using MTR map (Fig. 1B), ADC map (Fig. 1C), and FA map (Fig. 1D) respectively. ROI placement was done at three anatomical levels: the distal radioulnar joint (RU), pisiform (PL), and hamate hook (HH). The mean values obtained from at three different part of median nerve were compared by analysis of variance (ANOVA) with Scheffé post hoc analysis. The comparison on the basis of age was evaluated with Spearman's rank correlation test. A value of $p < 0.05$ was considered significant.

Result: The mean normative CSA, FR, and SNR were 7.64 ± 2.69 , 0.55 ± 0.16 , and 11.41 ± 3.47 , respectively. There was a significantly increase with advancing age in CSA at the level of RU ($p < 0.05$). The mean normative FR at the level of HH was significantly lower than that of other levels ($p < 0.05$). We found the normative MTR of median nerve were 0.47 ± 0.03 . There was no significant difference between MTR obtained at three levels (Fig. 2). The mean normative diffusion values of the median nerve were ADC of $1.03 \pm 0.14 \times 10^{-3} \text{ mm}^2/\text{s}$ (Fig. 3) and FA of 0.65 ± 0.08 . FA of the level of HH was significantly lower than that of the level of the RU ($p < 0.01$) and PL ($p < 0.05$) (Fig. 4). There was a statistically significant decrease with advancing age in FA at the level of HH ($r = -0.53$, $p = 0.02$). In a patient with CTS, the mean MTR, ADC, FA, CSA, FR, and SNR were 0.47, 0.94, 0.71, 6, 0.36, and 14.7. The MTR of CTS and normal volunteers were almost same. SNR and FA were not 2SDs above the normal value although they were tended to higher than that of the mean normative value. And ADC and FR were not 2SDs below the normal value although they were tended to lower than that of the mean normative value.

Conclusion: Assessing MTR of median nerve is feasible on the 3T MR imager within clinical scan times. The normative MTR, ADC, FA, CSA, FR, and SNR of the median nerve collected can be used as a reference for further studies in evaluating the role of these quantitative MR measurements in the evaluation, diagnosis, and follow-up of CTS.

Reference: [1] Kleindienst et al. Acta Neurochir 1996; 138: 228-33 [2] Radack et al. AJR Am J Roentgenol 1997; 169: 1649-53

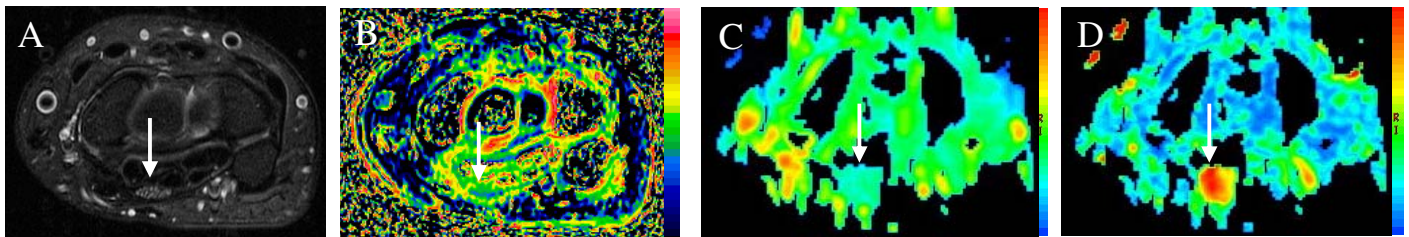


Figure 1. 28-year-female normal volunteer. FS-FSET2 (A), MTR map (B), ADC map (C), and FA map (D) show median nerve (arrow) at the level of pisiform.

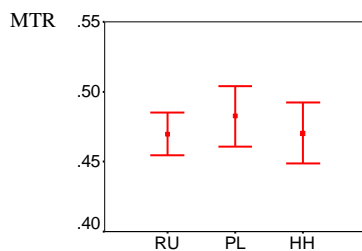


Figure 2. MTR at the level of RU, PL, and HH

The mean normative MTR of the level of distal radioulnar joint (RU), pisiform (PL), and hamate hook (HH) were 0.46 ± 0.02 , 0.48 ± 0.04 , and 0.47 ± 0.04 , respectively.

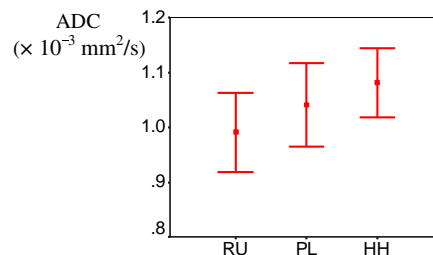


Figure 3. ADC at the level of RU, PL, and HH

The mean normative ADC of the level of RU, PL, and HH were 0.90 ± 0.14 , 1.04 ± 0.15 , and 1.08 ± 0.12 , respectively.

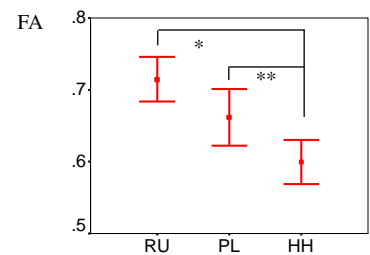


Figure 4. FA at the level of RU, PL, and HH

The mean normative FA of the level of RU, PL, and HH were 0.70 ± 0.06 , 0.66 ± 0.07 , and 0.59 ± 0.06 , respectively. * $p < 0.01$, ** $p < 0.05$