Feasibility of High-Resolution Pituitary MRI at 7.0 Tesla

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Background & Purpose: Microadenomas of the pituitary gland are an important cause of Cushing's disease. Due to its superior soft-tissue contrast, Magnetic Resonance Imaging (MRI) is the clinical imaging method of choice when visualizing lesions of the pituitary gland (1). However, since microadenomas can be as small as a few millimeters or less, it is important to aspire highest spatial resolution possible. At a high fieldstrength like 3.0 Tesla (T) or even 7.0T, the increase in signal-to-noise ratio (SNR) will enable sequences with a high spatial resolution without substantially increasing scan time (2). However, prolonged T_1-values, a higher specific absorption rate (SAR), increased susceptibility effects and radiofrequency magnetic field (B_1) inhomogeneities may hamper visualization of the pituitary gland (3), especially with regard to its caudal location in-between air-filled cavities. The aim of this study was to develop a clinical MRI protocol to visualize the pituitary gland at 7.0T.

Methods:

Institutional Review Board approval was obtained for this prospective study, and all subjects gave informed consent. Imaging was performed on a 7.0T MR system (Philips Healthcare, Cleveland, OH, USA) with a 32-channel receive coil and volume transmit/receive coil for transmission (Nova Medical Inc., Wilmington, MA, USA). First, 10 healthy volunteers were imaged to optimize a dedicated 7.0T protocol for pituitary gland imaging. After optimization, the protocol consisted of a 3D T_1-weighted (T_1w) TFE sequence, a 3D T_2-weighted (T_2w) TSE sequence and a 3D T_1w Magnetization-Preparation Inversion Recovery Turbo Spin Echo (MPIR-TSE) sequence (4), each with whole-brain coverage. Scan parameters can be found in the Table. This protocol was then tested in another ten healthy volunteers, and was also applied in a clinical setup for two patients. For the patients, an additional dynamic T_1w TSE sequence and a post-contrast T_1w TSE scan were obtained after administration of a Gadolinium-containing contrast agent (Gadobutrol 0.1 mL/kg). Image quality, image contrast, and pituitary gland coverage (including partial volume effects) of the 7.0T images were evaluated. Image quality was assessed by two observers. In case of differing assessment, consensus was reached. Assessment was based on 10 items (3) divided into 3 categories; visualization of anatomy, influence of artifacts and overall image quality. Pituitary gland coverage was evaluated by counting the amount of slices covering the pituitary gland. For the patients a clinical diagnosis was made based on previously obtained 1.5T data and 7.0T images.

Table. *Scan parameters*

Scan parameter	T_1w TFE	T_1w MPIR-TSE	T_2w TSE
FOV (mm)	200x250x200	250x250x190	250x250x190
Acquired resolution (mm)	1.0x1.0x1.0	0.8x0.8x0.8	0.7x0.7x0.7
TR/TI (ms)	8/1200	3952/1375	3200/-
TE/equivalent TE (ms)	1.97/-	37/19	300/58
Flip angle (degrees)	8	150	120
TFE/TSE-factor	140	158	182
NSA	1	2	2
SENSE factor (APxRL)	2x3	2x3	2x2.8
Duration (min:sec)	8:08	10:40	10:24

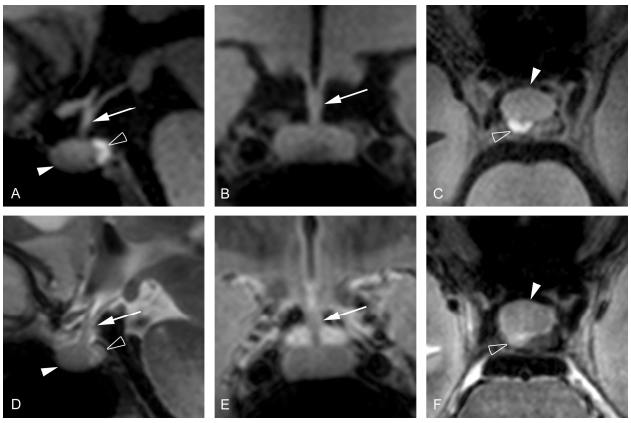

Figure 1. *T_1w MPIR-TSE sequence (A-C) and T_2w TSE sequence (D-F) in sagittal (A,D), coronal (B,E) and transverse (C,F) direction, showing the adeno- (white arrowhead) and neuro-hypophysis (open arrowhead) as well as the pituitary infundibulum (white arrow).*

Results:

The pituitary gland could be visualized well on 7.0T MRI using the T_1w MPIR-TSE sequence combined with the T_2w TSE sequence. Image quality of the T1w TFE sequence was assessed as poor, mainly due to susceptibility effects. In contrast the T_2w TSE sequence and T_1w MPIR-TSE sequence showed good visualization of the anatomy, and artifacts did not influence image quality (Figure 1). Mean pituitary gland coverage was on average 2-4 times increased at 7.0T as compared to 1.5T (8-17 slices versus 4 slices through gland). Contrast ratio of the neuro- and adeno-hypophysis was evaluated in the T_1w MPIR-TSE sequence and the T_2w TSE sequence. Poor image quality of the T_1w TFE sequence hampered assessment of contrast ratio in this sequence. Signal intensity of the neuro-hypophysis was higher than in the andeno-hypophysis in all ten cases, leading to a neuro/adeno contrast ratio >1.0 (mean 1.608; range 1.12-2.41). Evaluation of the T_2w TSE sequence showed a similar effect in eight of the ten subjects. The mean contrast ratio in the T_2w TSE sequence was 1.174 (range 0.88-1.42). In one patient no lesion was visible on either 1.5T or 7.0T images. The other patient showed one lesion, suspected for a microadenoma, on 1.5T images, but this lesion could not be found on the 7.0T images. A second lesion was visible at 7.0T, however the enhancement pattern of this lesion was not characteristic for a microadenoma, but most likely a cleft filled with cerebrospinal fluid. (Figure 2) Surgically obtained tissue confirmed the absence of a adenoma.

Conclusion:

This study shows that imaging of the pituitary gland at 7.0T MRI is feasible with a protocol consisting of a T_1-weighted MPIR-TSE sequence and a T_2-weighted TSE sequence. Highly detailed visualization of the pituitary gland is possible without numerous issues regarding to especially susceptibility effects. This dedicated protocol for the pituitary gland at 7.0T could prove to have additional value in the clinical setting.

References:

1. Shah et al. Best Pract Res Clin Endocrinol Metab 2012; 26(1): 35-46 2. Wolfsberger et al. J Neurosurg 2004; 100(2):278-86 3. Kakite et al. Eur J Radiol 2011; 79(1):108-12 4. Van der Kolk et al. Stroke 2011; 42(9): 2478-84

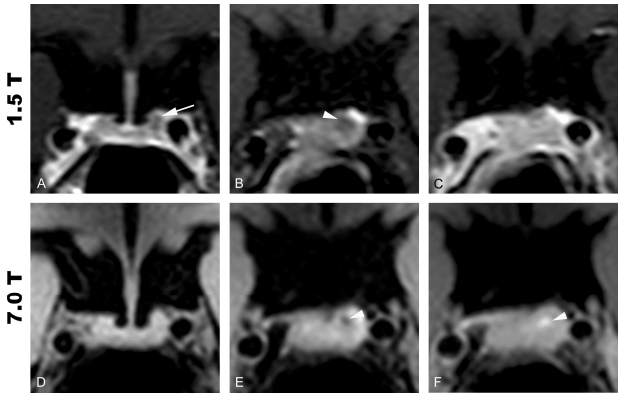

Figure 2. *T_1w MPIR-TSE images of a clinical patient with Cushing's disease. One lesion (arrow) was visible after contrast administration on 1.5T (A), but enhancement was absent on 7.0T (D). A second lesion (arrowhead) was hypointense on both pre-contrast images at 1.5T (B) and 7.0T (E), but enhancement remained absent on 1.5T (C) while on 7.0T this second lesion enhanced after contrast administration (F).*