T2 Hypointensity in the Deep Gray Matter of Patients with Multiple Sclerosis: Different Characteristics on 3.0 Tesla MRI

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Introduction

Abnormal reduction of signal intensity (SI) of deep gray matter (GM) on T2-weighted MR images (T2WI) in patients with multiple sclerosis (MS) was noticed more than a decade ago, and attributed to excessive iron deposition (1). The abnormal hypointensity can be the more extensive hypointensity in structures that normally show T2 hypointensity, or the hypointensity in GM structures that do not normally show T2 hypointensity. Although its radiological usefulness was not apparent in an early study (2), recent studies found this hypointensity was significantly related to longer disease duration and advanced neurological disability (3, 4). More recently, deep GM hypointensity quantified as the ratio of deep GM SI to SI of ventricular CSF was found to be associated with other MR measures, and to be a strong predictor of disability and clinical course (5). With the increasing use of 3.0 T MR scanners in clinical settings (6), we hypothesize that T2 hypointensity of deep GM will have different characteristics on 3.0 T than on 1.5 T, and that 3.0 T will be more sensitive to T2 hypointensity of deep GM. We are conducting a study comparing 3.0 T MRI with 1.5 T MRI in evaluation of pathological changes in MS. Initial results with regard to deep GM T2 hypointensity are reported here.

Materials and Methods

Eight patients with MS (mean age 40.0 years, range 29-54 years; M:F = 2:6; mean disease duration 7.6 years, range 1-16 years; mean EDSS score 3.3, range 1.5-7.5) were imaged. T2WI were acquired on a 1.5 T scanner (Signa; GE Medical Systems, Milwaukee, WI) using a dual-echo fast spin-echo sequence (TR/TE1/TE2=4000/15/80 ms, ETL=8, NEX=1, FOV=22 cm, matrix=256x192, thickness/gap=3/0 mm, bandwidth=±15.6 KHz). After 48 to 72 hours, 3.0 T images were acquired on a 3.0 T scanner (Signa; GE Medical Systems) with the same protocol.

We identified the following deep GM structures on 3.0 T images: head of caudate, thalamus, putamen, globus pallidus, red nucleus, and substantia nigra. Regions-of-interest (ROIs) were manually drawn on each deep GM structure on the slice showing their greatest cross-section. The margins of each deep GM were traced as closely as possible. The Virchow-Robin perivascular spaces were avoided. ROIs of cortical GM were drawn on multiple areas of frontal and temporal cortical GM on the slice on which the ROIs for putamen were drawn. ROIs of CSF were drawn on bilateral lateral ventricles on the slice on which the ROIs for the head of caudate were drawn. Mean SI of each structure was measured from bilateral ROIs. For each patient, 1.5 T images were spatially registered to 3.0 T images. Then the ROIs drawn on 3.0 T images were projected onto the registered 1.5 T images, and the SI at 1.5 T was measured. This ensured that the structure being measured on 3.0 T images was the same as on 1.5 T. All measurements were repeated three times by the same operator.

Relative SI of each deep GM structure was calculated as a ratio of measured deep GM SI to SI of ventricular CSF (5). A paired t-test was performed to compare the relative SI at 3.0 T with that at 1.5 T. SI change at 3.0 T compared with 1.5 T of each deep GM structure was calculated as the difference in measured SI between two scanners divided by the SI at 1.5 T. A paired t-test was performed to compare the SI changes of deep GM with SI changes of cortical GM.

Results

Significant difference in relative SI between 3.0 T and 1.5 T was found in every deep GM structures (Table). While the SI of cortical GM at 3.0 T increased by 42%, the SI of globus pallidus, red nucleus, and substantia nigra decreased. Although putamen also showed increased SI at 3.0 T, the increase was significantly smaller than that of cortical GM (Table). By visual inspection, T2 hypointensity was mild in general in this patient group, but better delineated on 3.0 T images (Figure).

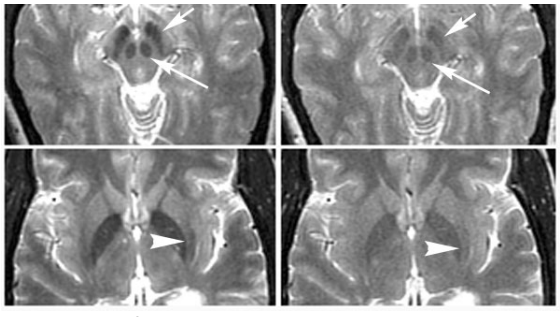
Discussion

The different relative SI of deep GM at 3.0 T indicates that measures of deep GM SI on 1.5 T cannot be applied directly to 3.0 T. The difference in relative SI can be explained by the SI change of reference structure (i.e. CSF) as well as the deep GM structures. The varying extent of SI changes at 3.0 T of deep GM structures may be explained by the varying content of iron in individual deep GM structures. The head of caudate and thalamus did not demonstrate SI change significantly different than cortical GM. This may be because of little iron deposition in these structures in this small group of patients. The other four deep GM structures demonstrated SI changes (decrease or smaller increase) significantly different from cortical GM. This results in greater contrast between iron-deposited and non-iron-deposited GM at 3.0 T, and, therefore, higher sensitivity of 3.0 T in detecting iron-deposition in deep GM. These results suggest a potential advantage of 3.0 T MRI in studying MS brain pathology.

Table. *Signal intensity (SI) of deep gray matter (GM) at 3.0 T vs. 1.5 T from eight MS patients*

	Relative SI*			SI change†	
	1.5 T Mean (SD)	3.0 T Mean (SD)	P Value§	Mean (SD)	P value‡
Head of caudate	0.51 (0.04)	0.41 (0.04)	0.001	30% (58%)	0.164
Thalamus	0.45 (0.04)	0.36 (0.03)	0.002	31% (59%)	0.211
Putamen	0.48 (0.04)	0.36 (0.03)	<0.001	16% (52%)	0.015
Globus pallidus	0.37 (0.03)	0.22 (0.03)	<0.001	-26% (51%)	<0.001
Red nucleus	0.38 (0.03)	0.26 (0.03)	<0.001	-1% (58%)	0.002
Substantia nigra	0.37 (0.04)	0.24 (0.02)	<0.001	-12% (49%)	<0.001

**Relative SI = GM SI / CSF SI.. §Paired t-test. †SI change = (3.0 T SI – 1.5 T SI) / 1.5 T SI. ‡Paired t-test, comparing SI change of deep GM with that of cortical GM (mean 42%, SD 63%).*



3.0 T *1.5 T*

Figure. *Deep gray matter at 3.0 T compared with 1.5 T. The display window width/level is adjusted for optimal cortical gray matter/white matter contrast. The red nuclei and substantia nigra (arrows), posterior putamen (arrow head), and globus pallidus have greater contrast and appear much darker at 3.0 T.*

References

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