7T MRI for neurodegenerative dementias in vivo: a systematic literature review

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Cho, Z. H., et al., 2010. Direct visualization of deep brain stimulation targets in Parkinson disease with the use of 7-tesla magnetic resonance imaging. J. Neurosurg. 113, 639–647
Aim and methods:

To systematically describe and evaluate published studies which have used 7T MRI in vivo in subjects with AD, LBD, FTD and HD.

To discuss gaps in the current literature and potential future applications for this technology in neurodegenerative dementias.

Key words:
“7T” OR “7 Tesla” OR “seven tesla” OR “ultrahigh resolution” AND “MR” OR “MRI” OR “magnetic resonance imaging” AND “neurodegen*” OR “Mild cognitive impairment” OR “MCI” OR “Alzheimer’s” OR “AD” OR “Lewy body dementia” OR “LBD” OR “Parkinson’s disease dementia” OR “PDD” OR “Frontotemporal dementia” OR “FTD” OR “Huntington*” OR “HD”
| Neurodegenerative Dementia | 7T MRI Publications | | | |
|---------------------------|---------------------|-----------------|-----------------|
| Alzheimer’s disease:      | 19 papers            | 15 papers       |
| Huntington’s disease:     | 4 papers             | 4 papers        |
| Lewy body dementia and   | 0 papers             | 0 papers        |
| frontotemporal dementia: |

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<thead>
<tr>
<th>Method</th>
<th>Structural Imaging</th>
<th>Susceptibility-weighted Imaging</th>
<th>Susceptibility-weighted Imaging</th>
<th>Iron Deposition</th>
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<td>Alzheimer’s disease:</td>
<td>7 papers</td>
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<td>Huntington’s disease:</td>
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<td>Lewy body dementia and</td>
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<th>Hippocampal Subfields</th>
<th>Amyloid deposition, microbleed prevalence</th>
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<th>Iron deposition</th>
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Alzheimer’s disease – structural imaging
Summary of findings:

- Very high in-plane resolution (~0.2 x 0.2mm)

- Increased effect size:
  - differentiation of MCI as well as AD from controls (when ApoE e4 status taken into account)
  - changes in minute subfields detected (e.g. in CA1-SRLM)

- Correlations between imaging findings and cognitive test results

- Limitations:
  - differences in post-processing techniques...different degrees of dementia...small subject numbers
  - no longitudinal data

- Potential adverse effects/ excessive movement artefact/ poor scan tolerability NOT found
Hippocampal subfields:

7T MRI showing segmentation of the hippocampus
CA = cornu Ammonis, ERC = entorhinal cortex, SUB = subiculum, DG = dentate gyrus)

7T MRI showing segmentation of hippocampal subfields (CA = cornu Ammonis, ERC = entorhinal cortex, SUB = subiculum, DG = dentate gyrus).

Susceptibility weighted imaging – AD and HD

Summary of findings:

- 7T MRI especially sensitive to susceptibility
- Variety of acquisition techniques...
- ...illuminating a variety of pathologies in vivo...
- ...‘revealing’ pathology not seen at lower field strengths
- AD papers conclude AMYLOID is most likely origin...
- ...reviewed HD papers conclude IRON is the most likely origin...
- Post-mortem (combined histology/ MRI) studies regarding 7T SWI effect origin inconclusive...
- ...correlations reported with amyloid deposits, microscopic iron and activated microglia, changes in myelination...
Alzheimer’s disease – microbleeds:

- Chronic hemosiderin deposits
- Associated with cerebrovascular disease
- Multiple microbleeds may suggest poor prognosis
- Presence of microbleeds in some exclusion criteria

Microbleed Prevalence

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<th>Control</th>
<th>MCI/AD</th>
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<td>3 Tesla</td>
<td>17</td>
<td>33</td>
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<tr>
<td>7 Tesla</td>
<td>44</td>
<td>78</td>
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aMCI – iron and amyloid:

Key points:

• Ultra-high resolution = improved visualisation/ measurement of small, complex structures

• Very sensitive to susceptibility effects = improved imaging of iron, microbleeds, amyloid

• Scans well-tolerated in patient groups

• Excessive movement artefact not unduly problematic
Future applications:

Seven tesla Siemen’s MAGNETOM Terra at Wolfson Brain Imaging Centre, University of Cambridge.
7T scans acquired at Wolfson Brain Imaging Centre, University of Cambridge
Dementia with Lewy bodies (DLB) is the second most common form of degenerative dementia in older people. Several key areas in investigation of dementia with Lewy bodies (DLB) are challenging to visualise using MRI at current field strengths. For instance, normal variation in cortical layers and subcortical nuclei. Ultra-high resolution MRI can potentially overcome major limitations of lower field strength MRI leading to better understanding of the role of structural brain changes, iron deposition and inflammatory changes in DLB.

On reviewing the literature, no 7T MRI in vivo studies with DLB publications were identified.

Hypotheses

In the brains of the DLB group we hypothesise that we will see:
- Changes in brain morphometry – including in small complex brain regions (e.g. hippocampal subfields, thalamic nuclei, basal ganglia)
- Changes consistent with increased iron deposition – including in thalamic nuclei and basal ganglia structures (globus pallidus, putamen and substantia nigra)
- Changes on MR spectroscopy consistent with inflammation in occipital cortex and basal ganglia.
- In vivo MRs will reveal changes in glutamate and GABA in the occipital lobe, which will correlate with hallucinations.

We hypothesise correlation between the imaging measures and that MRI findings will correlate with:
- Peripheral blood markers of systemic inflammation and neurocognitive test results.

Currently recruiting and collecting pilot data.

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Acknowledgements:

• McKiernan and O'Brien. 7T MRI for neurodegenerative dementias in vivo: a systematic review of the literature. J Neurol Neurosurg Psychiatry Published Online First: 04 March 2017. doi: 10.1136/jnnp-2016-315022