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A dedicated brainstem approach to assess loss of dorsolateral nigral hyperintensity: A study using 3T SWI, R2* and QSM for the diagnosis of Parkinson's disease

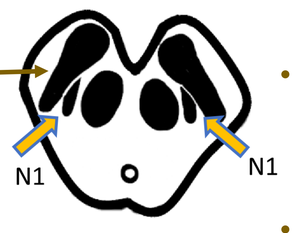
SABRINA HOUIDEF[1], GERMAIN ARRIBARAT[1], PATRICE PÉRAN[1]

1. ToNIC, Toulouse NeuroImaging Center, Université de Toulouse, Inserm, UPS, France

Introduction

- Within the brainstem of patients with **Parkinson's disease**, the **substantia nigra (SN)** shows **pathophysiological changes**

Substantia Nigra
- SN pars reticulata
- SN pars compacta



→ **Iron overload** in the **SN pars compacta** has been observed in this condition since 1924

- While essential for physiological brain function, **iron accumulation** in certain nuclei appears to be correlated with **neurodegenerative diseases** such as **Parkinson's disease**

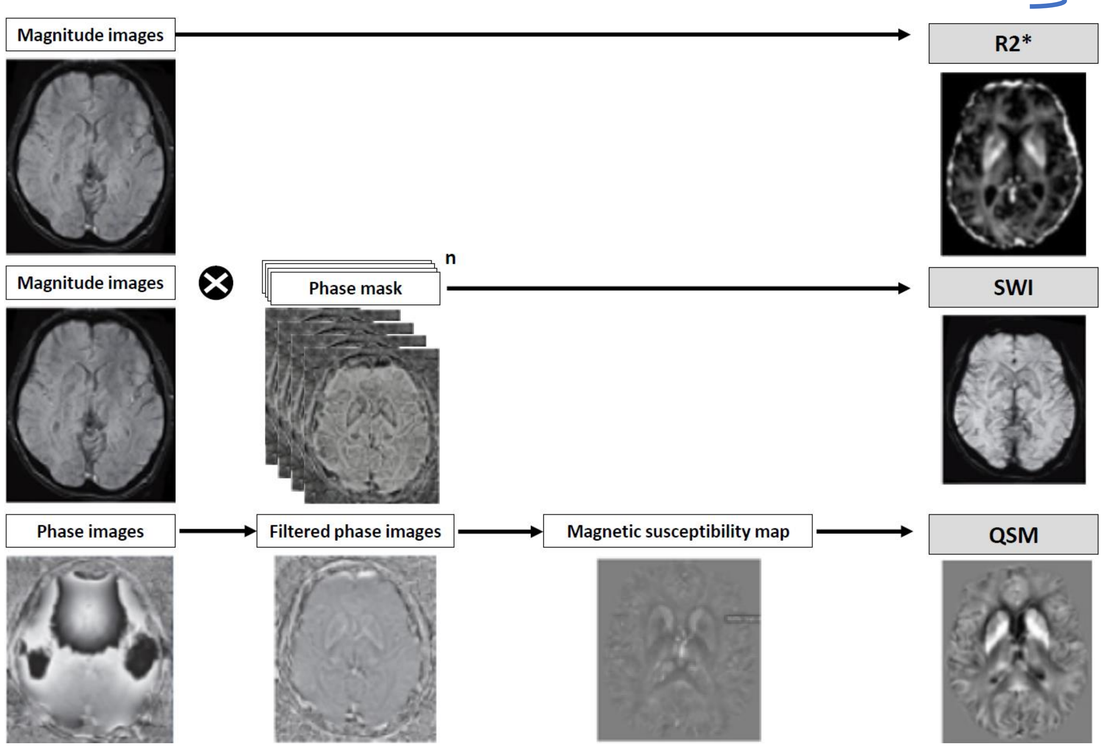
- Susceptibility-weighted imaging (SWI) allows the visualization of a hypersignal of the dorsolateral area of the SN pars compacta: **dorsolateral nigral hyperintensity (Nigrosome 1 – N1)** in healthy volunteers, at high field.
- The **disappearance of this hypersignal** would be a **pathophysiological marker of Parkinson's disease** associated with an **increase in iron**

Quantification of brain iron by magnetic resonance imaging (MRI) is of utmost importance
→ **Correlate the signal visualized with SWI with parametric maps, to quantify iron content**

Materials and Methods

- 3T MRI scanner Philips ACHIEVA dStream 32-channel head coil
- 16 healthy subjects aged 18 to 40 years were recruited

a 3D optimized brainstem-dedicated multi-echo gradient echo sequence (3D-mGE)
- Resolution: 0.67 mm × 0.67 mm × 1.4 mm
- Acquisition time: 5 min 45 s
- This sequence was repeated 5 times for each healthy volunteer



R2* RELAXOMETRY

- Use of magnitude images
- R2* parameter → indirect **iron quantification** (sensibility to local field inhomogeneity)

$$S(TE) = S_0\, e^{\frac{-TE}{T_2^*}} = S_0\, e^{-TE.R2^*}$$

SUSCEPTIBILITY-WEIGHTED IMAGING (SWI)

- Phase mask defined from phase images

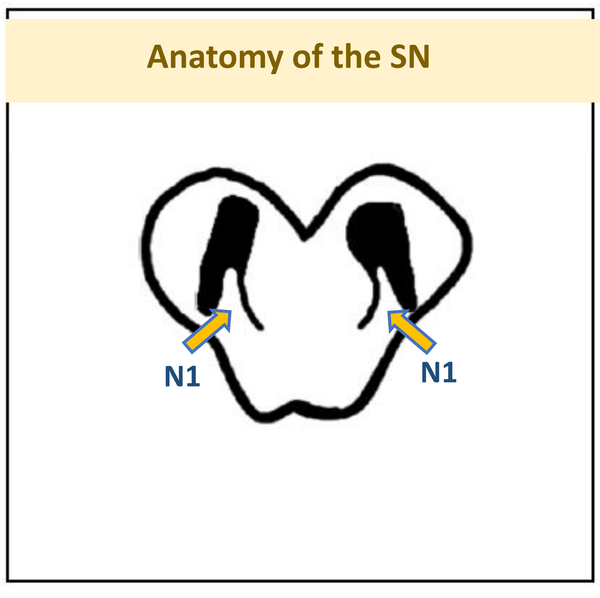
$$S_m(\chi) = \begin{cases} 0, \chi_s < \chi \\ (\chi_s - \chi)/\chi_s \quad 0 < \chi < \chi_s \\ 1, \quad otherwise \end{cases} \qquad \rightarrow \text{SWI} = (S_m)^n \times magnitude$$

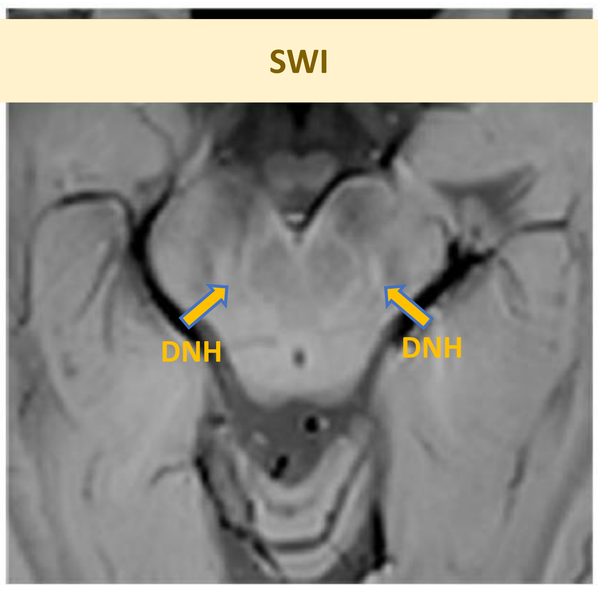
QUANTITATIVE SUSCEPTIBILITY MAPPING (QSM)

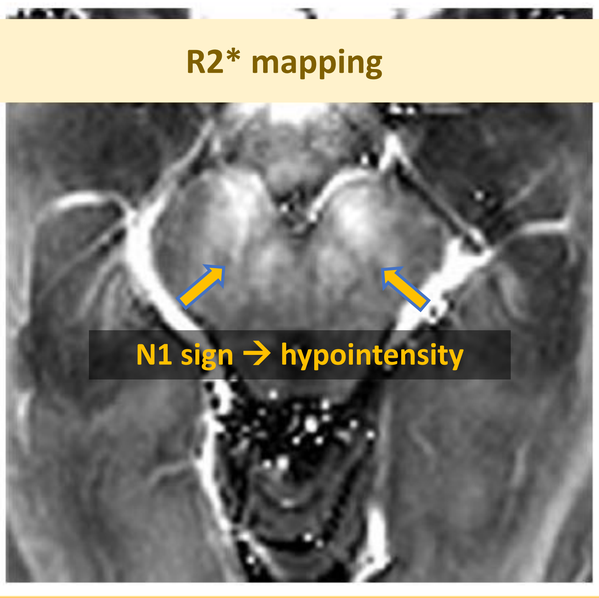
- Reflects the concentrations of paramagnetic or diamagnetic substances → measuring local changes in susceptibility in tissues

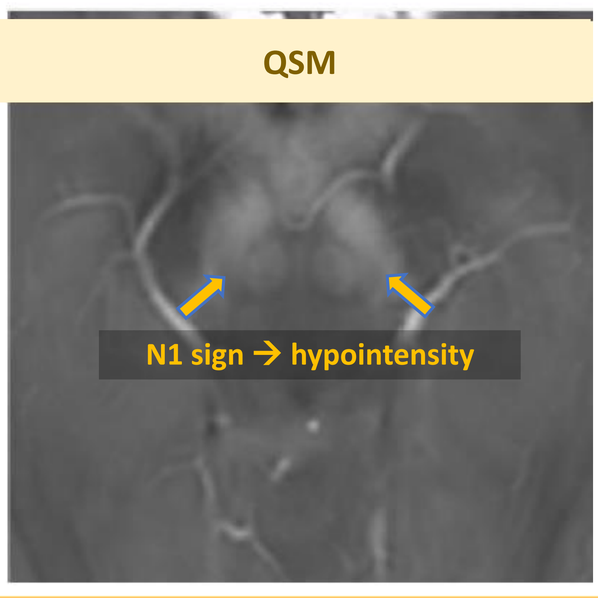
Phase unwrapping + Filtering → Background field removal → Dipole inversion

Results









Conclusion

- **Our brainstem-dedicated approach allows systematic visualization of the Nigrosome 1 in healthy subjects at 3T on several slices**
- Correlation of the DNH, visualizable on SWI, with parametric maps:
  - R2* map: N1 sign perfectly visualizable as a hypointensity → Useful to quantify iron in the N1
  - QSM: very complex mapping to perform and less reproducible than R2* mapping
    - DNH not easily detectable

References

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