

The normal anatomy of the substantia nigra using high field 9T MRI: correlation of postmortem images and histopathology

M. A. Miranda¹, L. A. Massey², H. G. Parkes¹, S. Po-Wah³, J. S. Thornton¹, J. Holton², L. Mancini⁴, P. Cheshire², K. Strand², A. J. Lees⁵, T. Revesz², and T. A. Yousry¹

¹Brain Repair and Rehabilitation, Institute of Neurology, UCL, London, London, United Kingdom, ²Queen Square Brain Bank for Neurological Disorders, Institute of Neurology, UCL, London, London, United Kingdom, ³Biological Imaging Centre, Imaging Sciences Department, Imperial College School of Medicine, MRC Clinical Sciences Centre, Hammersmith Hospital, London, London, United Kingdom, ⁴The National Hospital for Neurology and Neurosurgery, Lysholm Department of Neuroradiology, London, London, United Kingdom, ⁵Sara Koe PSP Research Centre, Institute of Neurology, UCL, London, London, United Kingdom

Purpose

We aimed firstly to describe the normal anatomy of the Substantia Nigra (SN) its boundaries, relationships and segments using high field 9.4T MRI of post mortem pathological specimens and secondly to correlate the high field MRI features with those found in histopathological sections of the same specimens.

Methods and Materials

Formalin fixed specimens were obtained from the Queen Square Brain Bank, IoN, UCL, London. Half-brain sections of the midbrain from controls with no neurological disease were imaged using a Varian 9.4T system with a multimodal MR protocol including high resolution T2WI (in plane resolution 49-125 microns) in the transverse axis, and volumetric acquisitions. The samples were then stained for myelin and with a Nissl stain and histological sections compared with axial MR images at approximately the same level.

Results

High resolution images allow clear identification of many brain stem structures including intrinsic nuclei and tracts. The relationships of those structures and the SN were clearly demonstrated. A 2 layer band with an antero-lateral low signal and postero-medial high signal on T2w images was seen in the superior midbrain between the Red Nucleus (RN) and the Cerebral Peduncle (CP) presumed to be the substantia nigra. Initial comparison with an atlas (Duvernoy 1992) points to this being the first demonstration of the pars reticulata and compacta of the Substantia Nigra on MRI. However, preliminary comparison with histological sections at the same level reveals some inconsistencies. The anterior extension of the SN into the anterior CP is questioned due to lack of exact correlation between our MRI Images and the pathology preparations although images taken from Duvernoy (stain: intravascular India ink injection) showed detailed correspondence. We hypothesize this is related to the type of stain used. The investigation of alternative stains is ongoing.

Conclusion

High field MRI of pathological specimens at 9.4T enables detailed visualization of midbrain structures with greater clarity than conventional *in vivo* MRI at 1.5/3T. A possible demonstration of the limits and relationships of the two segments of the substantia nigra was seen. The differentiation of these 2 entities has been previously elusive to MRI visualization.

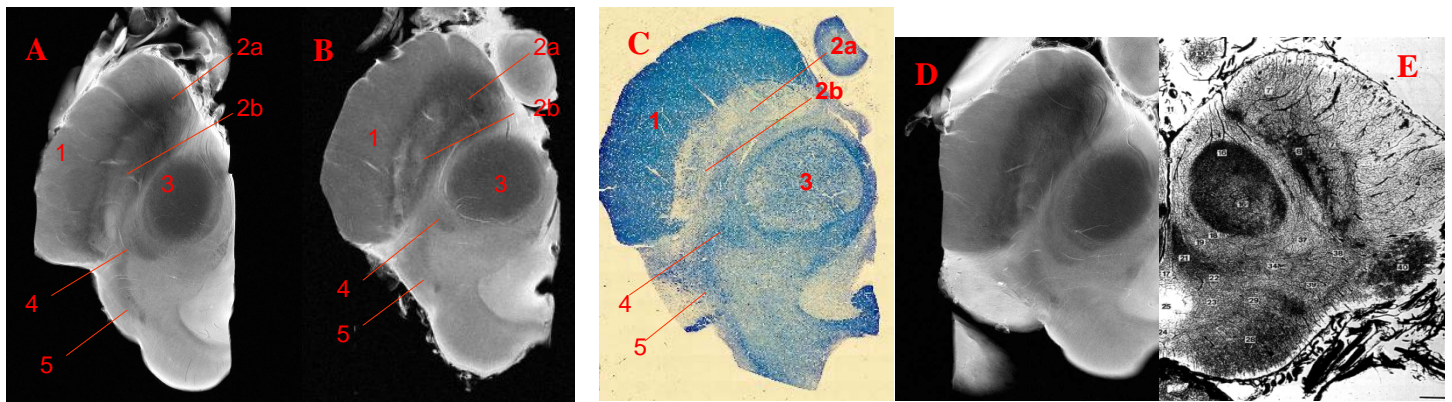


Figure A. T2High resolution image (in plane resolution 44 micrometers); Parameters: 9.4 T; FOV 45 x 45 mm; Matrix 1024 x 1024; TR 2000ms; TE 24ms; 0.5mm slice thickness; 1mm gap; scan time 75 hrs 30 mins. **Figures B and D.** High resolution image (in plane resolution 125 micrometers); Parameters: 9.4 T; FOV 50 x 50 mm; Matrix 512 x 512; TR 2000ms; TE 22ms; 0.5mm slice thickness; 1mm gap. Approximately 7 hr scan time. **Figure C.** Luxol fast blue and Cresyl Violet stained histological sections of corresponding MRI images. **Figure E.** Mirror image of D. Histological section of the midbrain taken from Duvernoy Atlas 1992 stained with intravascular India ink injection. **For all images** 1. Cerebral peduncle. 2a Substantia Nigra pars reticulata. 2b. Substantia Nigra pars compacta. 3. Red Nucleus. 4. Medial lemniscus. 5. Lateral Lemniscus

References

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