Visualizing Intrathalamic Structures with Combined Use of MPRAGE and SWI at 7T

Allen Newton[1,2], Benoit Dawant[3], and Pierre D'Haese[3]

[1]*Radiology and Radiological Sciences, Vanderbilt University, Nashville, TN, United States,* [2]*Institute of Imaging Science, Vandebrilt University, Nashville, TN, United States,* [3]*Electrical Engineering and Computer Science, Vanderbilt University, Nashville, TN, United States*

[Target audience] those interested in visualizing sub-thalamic structures in individual subjects/patients as well as investigators seeking methods to validate non-anatomic based thalamic parcellations

[Purpose] While studies have suggested the ability to parcellate sub-regions of the thalamus anatomically based on DTI tractography or functional connectivity, there is a need to identify a wide variety of intrathalamic structures anatomically on the individual level. Most studies attempt to identify these structures based either on differences in iron content via susceptibility weighted imaging (SWI), or the boundaries between structures are visualized through minimizing white matter signal[1,2]. However, these techniques can actually be complementary, and optimized parameters when using these strategies together need to be identified. We propose a series of optimized imaging strategies for visualizing intrathalamic structures. These methods allow for individual assessment of the location and volume of these nuclei, providing potential clinical appeal as well as the possibility for validation of functional and tractography based parcellation techniques.

[Methods] For demonstration purposes, two individuals were imaged at 7T using a quadrature transmit coil and a 32channel receive coil array. Two sequences were used for segmentation. The first was a susceptibility weighted image (SWI) acquired axially, which has been previously reported as being useful for segmenting some nuclei (slice selective gradient echo, FOV=240x180mm, vox.dim.=0.24x0.24x1mm, #sl=60, θ=45°, TR/TE=1952.3/23.13ms). The second was a 3D rapid gradient echo (MPRAGE400) with an inversion prepulse (FOV=246x246x174.3mm, vox.dim.=0.7x0.7x0.7mm, TR/TE/TI=4.74/2.1/400ms,shot interval=4500ms)**.** Intrathalamic structures were manually segmented on the individual level based on contrast in either image alone as well as by considering both images in combination, and locations were compared to atlas definitions according to the Morel atlas[3].

[Results and Discussion] In both individuals imaged, 12 subthalamic nuclei were successfully identified including: pulvinar nucleus (PU), centermedian nucleus (CM), medial dorsal nucleus (MD), ventral anterior nucleus (VA), ventral lateral nucleus (VL), ventral intermediate nucleus (VI), ventral posterior lateral (VPL), ventral posterior medial (VPM), anterior nucleus (AN), lateral dorsal nucleus (LD), parafasicular nucleus (PF), reticular perithalamic nucleus (Ret) *(Figure 1)*. Of these 12 intrathalamic structures, most were more clearly identifiable when both SWI and MPRAGE were used in combination than when using either image alone. Using these two images in combination is advantageous due to their reliance on distinctly different contrast mechanisms. Additionally, while other studies have suggested that longer inversion times in MPRAGE style acquisitions are advantageous for imaging intrathalamic structures, we present evidence here that inversion delays as short as 400ms provide useful information and allow for segmentation of structures not previously reported as being visible in these types of images[2].

[Conclusion] We have shown that several intrathalamic structures may be able to be anatomically visualized on the individual subject level with a combination of susceptibility weighted and T1 weighted images, if the proper imaging parameters are utilized. Furthermore, we suggest the utility of imaging with inversion delays shorter than has been recently suggested is optimal for contrast against white matter.

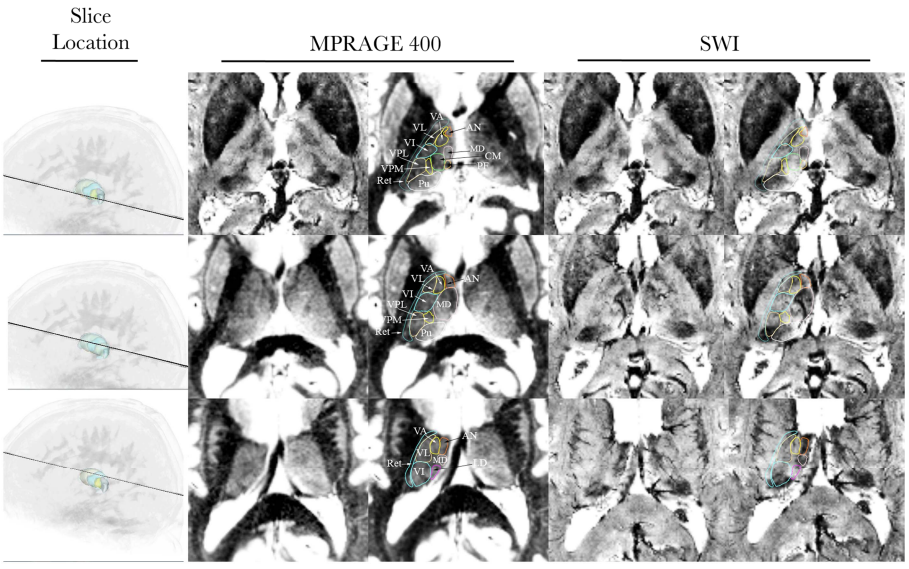

Figure 1: *axial views of intrathalamic structures from a representative subject. Rows represent different slice locations. In both image types, the left column shows the underlying image, which is annotated with substructure segmentations to its right. Many structures are visible based on T_1 contrast, though some segmentations were only possible when combined with information from SWI.*

[References] [1] Spiegelmann et al. Stereotactic Targeting of the Ventrointermediate Nucleus of the Thalamus by Direct Visualization with High-Field MRI. Stereotact Funct Neurosurg 2006;84:19–23. [2]Tourdias et al. Visualization of intra-thalamic nuclei with optimized white-matter-nulled MPRAGE at 7 T. NeuroImage 84 (2014) 534–545. [3]Niemann et al. The Morel stereotactic atlas of the human thalamus: atlas-to-MR registration of internally consistent canonical model. Neuroimage. 2000 Dec;12(6):601-16;

[Acknlowledgments] funding: NIH R01-EB006136