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Can We Rely on Susceptibility-Weighted Imaging (SWI) for Subthalamic Nucleus Identification in Deep Brain Stimulation Surgery?

To the Editor:

It is with great interest that we read the recent publication by Bot et al¹ in which a fundamental question for deep brain stimulation surgery for Parkinson disease was addressed: Which magnetic resonance imaging (MRI) sequence is best suited to visualize the subthalamic nucleus (STN)? In the article, the authors set out to test the influence of MRI contrasts on the precision of microelectrode recording (MER) contact sites in the STN in patients with Parkinson disease. For this, T₂-weighted images and susceptibility-weighted images (SWIs) were collected at 1.5 T MRI as well as T₂-weighted images 3T MRI. The authors report that, if the 1.5T SWI STN contour was used, the MER contacts are more frequently found outside the STN, especially in anterior and lateral direction in comparison with the 1.5T or 3T T₂-weighted scans. They conclude that the anterior-lateral region of the STN is not displayed correctly when using the SWI contrast and that, therefore, SWI offers a disadvantage compared with conventional T₂-weighted imaging.

Here, we would like to point out that, in our opinion, this conclusion is not entirely warranted. It is interesting to note that there is a mismatch between the location of MER contacts and the SWI-defined contours of the STN in the anterior-lateral part of the STN. This finding can be explained by the fact that SWI is sensitive to iron and that previous work has shown that there is less iron in the superior-lateral part of the STN.² In light of the inhomogeneous iron distribution in the STN and the lower contrast to noise of 1.5T MRI, SWI with lower field strength, such as 1.5T MRI, is suboptimal. However, SWI with higher field strength including 3T or 7T MRI provides a better contrast for the STN than T₂-weighted scans. In fact, it has been shown that SWI enormously benefits from higher field strengths (3T and higher) and can result in isotropic voxels with higher contrast to noise ratio in shorter scanning times compared with lower field strength, such as 1.5T MRI.^{3,4}

Another advantage of SWI volumes is that they are based on a gradient echo MRI sequence. The raw gradient echo data can be processed differently by a promising postimaging technique called quantitative susceptibility mapping (QSM).^{5,6} One of the advantages of QSM is that the nonlocal field perturbations in the phase images are removed and result in a more fine-grained and anatomically correct visualization of the STN.⁷

In light of these studies, which have repeatedly shown that SWI- and QSM-based contrasts result in superior visualization of the STN compared with T₂-weighted imaging,⁸⁻¹¹ we feel that the conclusion by Bot et al¹ does not reflect the consensus in the

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field. Instead of concluding that SWI is not suited to visualize the entire STN, one should be more specific and conclude that the combination of low MRI field strength is suboptimal.

Disclosures

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REFERENCES

1. Bot M, Bour L, de Bie RM, Contarino MF, Schuurman PR, van den Munckhof P. Can we rely on susceptibility-weighted imaging (SWI) for subthalamic nucleus identification in deep brain stimulation surgery? *Neurosurgery*. 2016;78(3):353-360.
2. de Hollander G, Keuken MC, Bazin PL, et al. A gradual increase of iron toward the medial-inferior tip of the subthalamic nucleus. *Hum Brain Mapp*. 2014;35(9):4440-4449.
3. Deistung A, Rauscher A, Sedlacik J, Stadler J, Witoszynskij S, Reichenbach JR. Susceptibility weighted imaging at ultra high magnetic field strengths: theoretical considerations and experimental results. *Magn Reson Med*. 2008;60(5):1155-1168.
4. Haacke EM, Mittal S, Wu Z, Neelavalli J, Cheng YCN. Susceptibility-weighted imaging: technical aspects and Clinical applications, part 1. *AJNR Am J Neuroradiol*. 2009;30(1):19-30.
5. Liu T, Eskreis-Winkler S, Schweitzer AD, et al. Improved subthalamic nucleus depiction with quantitative susceptibility mapping. *Radiology*. 2013;269(1):216-223.
6. Chandran AS, Bynevelt M, Lind CR. Magnetic resonance imaging of the subthalamic nucleus for deep brain stimulation. *J Neurosurg*. 2016;124(1):96-105.
7. Schäfer A, Wharton S, Gowland P, Bowtell R. Using magnetic field simulation to study susceptibility-related phase contrast in gradient echo MRI. *Neuroimage*. 2009;48(1):126-137.
8. Plantinga BR, Temel Y, Roebroek A, et al. Ultra-high field magnetic resonance imaging of the basal ganglia and related structures. *Front Hum Neurosci*. 2014;8:876.
9. O'Gorman RL, Shmueli K, Ashkan K, et al. Optimal MRI methods for direct stereotactic targeting of the subthalamic nucleus and globus pallidus. *Eur Radiol*. 2011;21(1):130-136.
10. Vertinsky AT, Coenen VA, Lang DJ, et al. Localization of the subthalamic nucleus: optimization with susceptibility-weighted phase MR imaging. *AJNR Am J Neuroradiol*. 2009;30(9):1717-1724.
11. Schäfer A, Forstmann BU, Neumann J, et al. Direct visualization of the subthalamic nucleus and its iron distribution using high-resolution susceptibility mapping. *Hum Brain Mapp*. 2012;33(12):2831-2842.

10.1227/NEU.0000000000001395

In Reply: Can We Rely on Susceptibility-Weighted Imaging (SWI) for Subthalamic Nucleus Identification in Deep Brain Stimulation Surgery?

We thank Keuken et al for their interest in our recent publication, in which we report that subthalamic nucleus (STN) representation on 1.5-T susceptibility-weighted imaging (SWI) does not correspond to electrophysiological STN borders as measured by intraoperative microelectrode recordings; 1.5-T SWI does not correctly display the lateral part of the STN.¹ The (supero)lateral part of the STN is thought to be the sensorimotor part of the nucleus and the optimal target for deep brain stimulation in Parkinson disease.²⁻⁴ Because most deep brain stimulation neurosurgeons throughout the world currently use 1.5-T magnetic resonance imaging during stereotactic planning, we consider our findings on 1.5-T SWI of utmost importance to take into consideration during STN target planning.

We agree with Keuken et al that 3-T and 7-T SWI may offer significant benefits regarding STN visualization. We therefore stated in our abstract and conclusion that “future research is needed to determine whether these findings may also apply for high-field SWI.” Given the geographical proximity of our research centers, we hereby gladly invite Keuken et al for a cup of coffee to further discuss this intriguing research topic.

Disclosure

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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REFERENCES

1. Bot M, Bour L, de Bie RM, Contarino MF, Schuurman PR, van den Munckhof P. Can we rely on susceptibility-weighted imaging for subthalamic nucleus identification in deep brain stimulation surgery? *Neurosurgery*. 2016;78(3):353-360.
2. Parent A, Hazrati LN. Functional anatomy of the basal ganglia, II: the place of subthalamic nucleus and external pallidum in basal ganglia circuitry. *Brain Res Brain Res Rev*. 1995;20(1):128-154.
3. Coenen VA, Prescher A, Smidt T, Picozzi P, Gielen FL. What is dorso-lateral in the subthalamic nucleus (STN)? A topographical and anatomical consideration on the ambiguous description of today's primary target for deep brain stimulation (DBS) surgery. *Acta Neurochir (Wien)*. 2008;150(11):1163-1165; discussion 1165.
4. Rodriguez-Oroz MC, Rodriguez M, Guridi J, et al. The subthalamic nucleus in Parkinson's disease: somatotopic organization and physiological characteristics. *Brain*. 2001;124(pt 9):1777-1790.

10.1227/NEU.0000000000001416