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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 al[1] 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 recoding (MER) contact sites in the STN in patients with Parkinson disease. For this, $T_2$-weighted images and susceptibility-weighted images (SWIs) were collected at 1.5 T MRI as well as $T_2$-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 $T_2$-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 $T_2$-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 $T_2$-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 $T_2$-weighted imaging,[8-11] we feel that the conclusion by Bot et al[1] 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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## 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 target planning, we consider our findings on 1.5-T SWI of upmost 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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