Enhancing susceptibility weighted imaging through collaborative research

Kumamoto University Hospital, Japan, collaborates with Philips in research on improving susceptibility weighted imaging techniques

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Kumamoto University Hospital, Japan, contributes to the development of Philips susceptibility weighted imaging technology

At Philips we listen to our customers and continuously collaborate with our clinical partners on developing, testing and evaluating new methods. The insights and contributions of our customers feed into the development of new or improved features.
When Tetsuya Yoneda, PhD, physicist at Kumamoto University Hospital in Japan, had discussed his ideas on susceptibility weighted imaging with the Philips Japan clinical science team, it was the start of a fruitful collaboration. The results helped the Philips product development team.

Susceptibility weighted imaging is an MR imaging technique used to visualize susceptibility differences between tissues. Magnetic susceptibility represents the ability of a tissue to become magnetized in a magnetic field. Tissues and substances behave differently in a magnetic field, because they have different paramagnetic and diamagnetic properties that influence T2* and phase.

“The aim in susceptibility weighted imaging is to enhance contrast between materials with different susceptibility to visualize, for instance, deoxygenated blood as a result of the exposed iron it contains. Deoxygenated blood also appears dark on T2*-weighted images, but the sensitivity is higher on susceptibility weighted imaging,” says Dr. Yoneda.

“Susceptibility weighted imaging also uses phase information, which depends on field strength, so the effect is stronger on a 3.0T system,” says Dr. Yoneda. “That is why we worked with the Achieva 3.0T TX system. We mainly use the 32-channel head coil as it provides very nice quality imaging.”

Redesigning data reconstruction

“I have worked on the reconstruction algorithm of susceptibility weighted imaging data. The initial susceptibility weighted imaging methods were based on differences in paramagnetic properties, which is sufficient to visualize hemorrhage that contains deoxygenated blood. Additionally, I explored the possibility to make the method sensitive to diamagnetic materials, which could also allow visualization of accumulations containing diamagnetic materials, such as calcifications.”

Balancing scan parameters

In collaboration with technologists, neuroradiologists, medical doctors and the Philips Japan MR team Dr. Yoneda finally achieved the desired results. “The mathematical function is now completely different. It enhances any kind of phase information and not just paramagnetic phase information like in the initial methods on our system,” says Dr. Yoneda. “Another difference is that the method eliminates the phase-wrapping artifact from the phase information. That phase wrap arises from long TE, but a long TE is desirable to generate high contrast on the phase information, so we had to find a compromise to get the good contrast.”

Visualizing fine anatomical structures

These images illustrate the power of the reconstruction with phase difference enhanced imaging (PADRE) to delineate fine anatomical structures. The left and middle images show many brainstem tracts with good contrast. These are very difficult to visualize on conventional MRI sequences. In the right image, neuronal nuclei in the thalamus are easily seen. The capability to delineate neuronal nuclei and tracts – with realistic scan duration, high spatial resolution, high contrast – may be a useful tool for investigating multiple system atrophy as in Parkinson’s disease and surgical procedures such as deep brain stimulation.

Achieva 3.0T TX, 3D-T1FFE, 0.5 x 0.5 x 2.0 mm (1.0 mm overcontiguous), TE 23 ms, TR 32 ms, scan time 3:40 min.

Images courtesy of Dr. Kitajima, MD, Kumamoto University.
“High sensitivity for venous blood products makes it possible to see hemorrhage and even microbleeds,” says Dr. Yoneda. “Using my method we have also imaged patients with neuro and brain diseases such as arteriovenous malformation, cortical displacement, degenerative diseases such as Parkinson’s disease, multiple sclerosis and multiple system atrophy. We are hoping to extend our work to the rest of the body.”

The collaboration between Dr. Yoneda and Philips is ongoing and focusing on further exploring together the potential of this technique.
SWIp, a fast method with exquisite contrast

In the SWIp method that was launched at RSNA 2013, Philips has included Dr. Yoneda’s algorithm in addition to some other innovations. SWIp is now in use at numerous sites around the world.

Philips SWIp technology delivers exquisite 3D high-resolution images with superb susceptibility contrast and a high sensitivity for venous blood products. This is due to a powerful combination of multi-echo acquisitions for high SNR and high image quality, along with image processing that is based on phase information. The short scan times and high reliability allow you to easily integrate it into your neuro exams. Phase maps can be made for advanced diagnosis.

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Different contrast types

MRI has the ability to use different scan methods to create different contrast types, which is an advantage over other modalities. Usually only the magnitude images are used, but phase difference enhanced imaging reconstruction could be applied to different sequences. In this way, different sequences can naturally make different background contrast, resulting in various types of SWIp-like contrast. We are currently studying the use of PADRE in different sequences to explore whether this could provide useful additions in clinical scanning, Achieva 3.0T TX.