UNMC advances 3.0T abdominal imaging

Dr. Hussain combines 16-channel SENSE XL Torso coil with e-THRIVE to enhance 3.0T abdominal imaging
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New 16-channel SENSE XL Torso coil combined with e-THRIVE enhances abdominal imaging at 3.0T

The Department of Radiology at the University of Nebraska Medical Center (UNMC), Omaha, Nebraska has been evaluating abdominal MRI using Philips’ latest 16-channel SENSE XL Torso coil and e-THRIVE imaging technique on their Achieva 3.0T system. The results to date have demonstrated that 3.0T abdominal imaging provides high image quality, high spatial resolution, good anatomical coverage, and a scan time that fits in a single, comfortable breath hold.

Although 3.0T MRI delivers twice the signal-to-noise ratio (SNR) of 1.5T, body imaging at 3.0T requires careful optimization to minimize effects of B1 inhomogeneities produced at the higher field strength, and to provide good fat suppression. In close collaboration with the UNMC’s Department of Radiology, Philips has recently developed an enhanced version of its 3D high resolution abdominal dynamic imaging technique called e-THRIVE specifically to address these issues. For the past year, Professor Shahid M. Hussain (M.D., Ph.D.) and his colleagues within the Body MRI Group at UNMC have been collaborating closely with Philips to assist in the further development and clinical evaluation of the new technique.

Fig. 1  e-THRIVE

Axial e-THRIVE shows a ring-enhancing liver lesion.
Note also the enhancement of the pancreas and the kidneys.
16-channel SENSE XL Torso coil exceeds expectations

e-THRIVE is a 3D T1-weighted TFE sequence with dual halfscan and improved fat-suppression that enables fast dynamic scanning with sub-millimeter in-plane resolution. It is a combination of established techniques, each of which has been carefully optimized for high homogeneity plus good fat suppression and contrast (see sidebar).

The UNMC group’s initial results were obtained using Philips’ 6-element SENSE Torso coil. Recently, however, the group has taken delivery of the latest 16-element SENSE XL Torso coil and, according to Professor Hussain, the results with this coil are exceeding everyone’s expectations.

“In a standard state-of-the-art liver exam, we normally start with single-shot images in axial and coronal directions and then go on to perform fat-suppressed, respiratory-triggered multishot images plus black-blood EPI with a b-value of about 20. This allows us to null the signal from the vessels and see the tiny lesions in the liver much better,” explains Professor Hussain. “This is a breath-hold sequence that provides similar type of info as we get from a respiratory-triggered sequence which can last 3 to 5 minutes. Then, of course, we can do MRCP if it is clinically indicated, and subsequently proceed with dynamic imaging starting with a pre-contrast 3D T1 weighted sequence to delineate the liver and evaluate pancreatic lesions. Finally we proceed to the arterial phase which we perform after BolusTrak.”

“With the new 16-element SENSE XL Torso coil we get unparalleled in-plane SSh-TSE resolution of 1 x 1 mm which is really spectacular.”

UNMC Radiology

UNMC is a major, nationally-recognized, transplant center in the USA. It offers a wide variety of transplants including bone marrow, small bowel, pancreas, kidney, and liver. Approximately 150 liver transplants are performed annually.

Since Dr Hussain joined the Department of Radiology – chaired by Craig W. Walker, MD, FACR – the number of state-of-the-art MRI exams has increased more than 10-fold over the past two years. Such exams play an important role in the clinical and surgical decision making of many patients, including patients with liver diseases. In addition to the high level of abdominal diagnostic exams, UNMC Radiology provides a full array of minimally-invasion treatments for liver lesion including trans-arterial chemo-embolization (TACE) and radiofrequency ablation (RFA). At the UNMC, state-of-the-art MR imaging plays an important role in the follow-up and monitoring of patients after TACE and RFA.

Visit www.philips.com/netforum for more on THRIVE and more images

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Dr. Hussain is Chief Abdominal Imaging and Herbert B. Saichek Professor of Radiology at UNMC. His current field of interest includes liver MRI and comparison of modalities (US, CT, PET, MRI) for hepatic imaging. He has won nine awards from professional organizations, including a Magna Cum Laude of RSNA 1995. Dr. Hussain is responsible for the body 3.0T program at the UNMC. Other important members of the collaborative team include Jennifer M. Oliveto, M.D., technologists Jeremy Van Tilburg, Ty Bremer, Patty L. Ladenson, of UNMC. They are supported by Tom Perkins, PhD, Jeroen Stout and Gwenael Herigault, PhD of Philips’ application and clinical-science groups.
e-THRIVE provides fast, high resolution, dynamic 3D imaging

For some years, the UNMC Radiology Department and Philips Medical Systems have been actively collaborating to optimize abdominal MRI at 3.0T. The fruits of this joint effort include e-THRIVE, a new 3D T1-weighted fast acquisition technique for abdominal, pelvis and breast imaging.

"Working with the Philips clinical scientists here in the US and in the Netherlands, we have optimized the 3D T1-weighted segmented gradient echo sequence for dynamic gadolinium-enhanced high-resolution liver imaging at 3.0T," points out Professor Hussain. "The sequence is based on linear k-space filling with near-isometric voxels. Firstly, fat suppression and overall image homogeneity were optimized by appropriately accounting for inherent water and fat signal variations across the segmented echo train. Secondly, robustness against motion was improved and arterial phase capture was optimized by early and fast sampling of the central part of k-space."

The sequence parameters include: TR/TE of 3.3/1.6 ms; a flip angle of 10; the acquired and reconstructed voxel sizes vary between 2.18 x 1.78 x 3.00 (interpolated to 0.75 x 0.75 x 1.5 mm) and 1.44 x 1.18 x 3.00 (interpolated to 0.70 x 0.70 x 1.5 mm). Eighty slices can be reconstructed to 160 slices in a single breath hold of 22 seconds. This sequence is also successfully used for other anatomic areas including chest MRI, and the near-isometric small voxels allow high-quality coronal and sagittal reformats.

Chest MRI

MRI in a patient with a large lung tumor at the right hilar region. The near-isometric spatial resolution allows high-quality multi-planar reformats. Achieva 3.0T X-series with 16-channel XL Torso coil.

"We’re confident that further optimization will result in 3.0T MRI becoming the new standard in abdominal imaging."
According to Professor Hussain the results the group is getting with the new coil – even without e-THRIVE – are very exciting. “The coil’s high SNR allows us to go to higher acceleration factors with SENSE, opening a whole range of new possibilities for us,” he explains. “Single-shot Turbo Spin Echo sequences, for example, are among the key sequences for abdominal MR imaging. SSh-TSE sequences are inherently characterized by low SNR and it is often not possible to increase the in-plane spatial resolution. In particular, at 1.5T with a 4-channel torso phased-array coil, SSh-TSE sequences have relatively lower in-plane matrix. At 3.0T, however, the combination of higher SNR and the 16-channel SENSE XL Torso coil allows unparalleled in-plane resolution of 1 x 1 mm. This is really spectacular and only possible on that coil. Our SSh-TSE sequences can even be performed on patients with ascites with good image quality.”

Fig. 2  Liver ascites
Coronal and axial SSh-TSE. Note the abundant ascites surrounding the liver and the spleen with diagnostic image quality. Achieva 3.0T X-series with 16-channel SENSE XL Torso coil.

Fig. 3  Left kidney cyst
Coronal SSh-TSE with 16-channel SENSE XL Torso coil. Images show exquisite image quality. Note the cortico-medulary differentiation of the kidneys with a large cyst in the right kidney (left image). The common bile duct and the pancreatic duct are visible, and several small and larger cysts in the liver.
Black-blood EPI for liver imaging

Working closely with Philips clinical scientists, the team has also developed an alternative for the SAR-intensive T2-weighted Turbo Spin Echo (T2W-TSE) sequences. “We optimized a fat-suppressed, black-blood echo planar sequence with low diffusion weighting,” he points out. Black-blood EPI is one of the cornerstones of abdominal MRI and according to Professor Hussain, requires a lot of fine tuning. “Our optimization procedure included using fewer frequency points than phase encoding steps in combination with a SENSE factor of 3, a TE of 45 ms with TR set to its shortest value, and reconstructing the acquired 2.0 x 1.4 x 5.0 mm voxel size to 0.8 x 0.8 x 5.0 mm. This resulted in high, sub-millimeter, in-plane spatial resolution, allowing 50 slices to be acquired in a single breath hold of 23 seconds.”

Using the 16-channel SENSE XL Torso coil, the new BB-EPI sequence can be used for liver imaging at 3.0T with similar image quality and fat suppression to what can be obtained from SAR-intensive TSE sequences. “BB EPI may eventually replace the lengthy and SAR-intensive Turbo Spin Echo sequences currently performed at 3.0T,” says Professor Hussain.

A powerful combination

Although Professor Hussain hasn’t yet built up a lot of experience with the new e-THRIVE technique using the 16-channel SENSE XL coil, his first impressions are that it creates a truly powerful combination.

“The combination gave significantly higher spatial resolution than we had ever achieved with the 6-element SENSE Torso coil, and we are now able to go to sub-millimeter in-plane resolution and even thinner sections. Image quality with this combination is substantially equivalent to what you can expect from CT, but without, of course, the hazard of x-ray radiation,” he points out. “We also have the impression that B1 inhomogeneities were also significantly reduced but we need to investgate further to confirm this.”

Initial results of the UNMC Radiology Department show that abdominal MRI at 3.0T can be successfully performed. “We have demonstrated that the higher SNR of 3.0T can be used to reduce the voxel size to provide sub-millimeter in-plane resolution, sufficient anatomic coverage, and relatively short scan times that fit in a single comfortable breath-hold,” emphasizes Professor Hussain. “We’re confident that further optimization with continuous improvements in image quality will result in 3.0T MRI becoming the new standard in abdominal imaging.”

“50 slices can now be acquired in a single breath hold of 23 seconds”
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References


