Large FOV Imaging at 3T with a 32-Channel Body Array Coil

Yutaka Natsuaki, Ph.D.; Gerhard Laub, Ph.D.

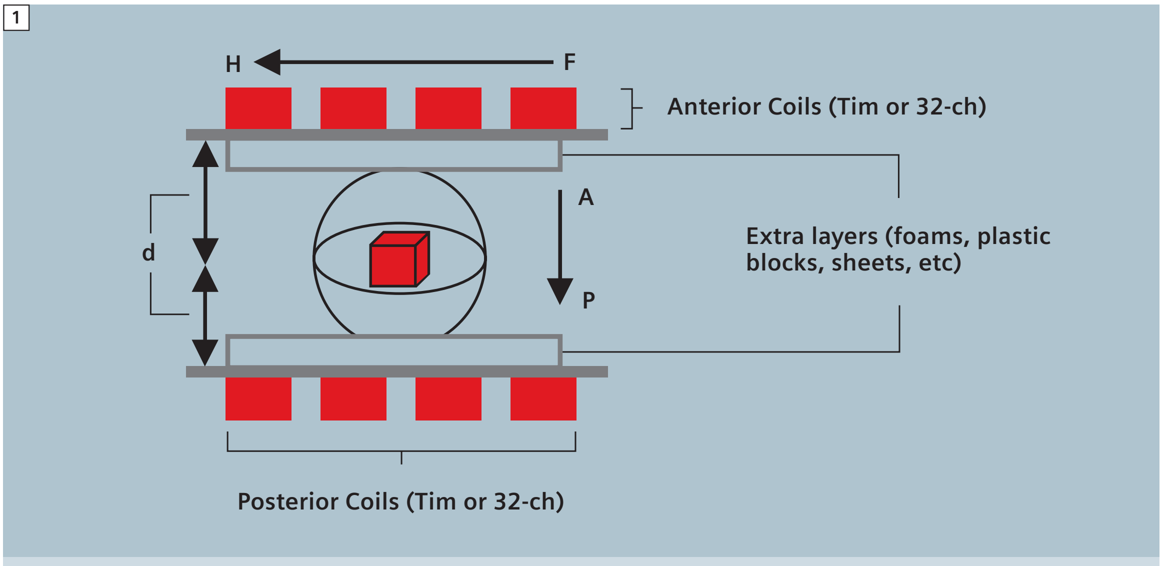
Siemens Medical Solutions, Inc., West Coast Team, MR R&D, Los Angeles, CA, USA

Introduction

Parallel imaging techniques have developed very rapidly, and realization of their full potential has required the development of MR systems with up to 32 receive channels. High-density RF array coils can be connected and utilized in a clinical environment in all Tim (Total imaging matrix) systems. Currently, Siemens offers two 32-channel array coils for brain and body applications, respectively. Both coils are available at 1.5T and 3T. In this article we will show the benefits of the 32-channel body coil for large FOV imaging in the abdomen, and pelvis, including MR Angiography.

Background

The 3T MR system has gained immense popularity among the diagnostic medical imaging community in recent years, largely due to the better image quality (e.g. higher resolution and better contrast) and the shorter scan time when compared to the conventional 1.5T MR system. These advantages in 3T MR system are made only possible by the combination of its inherently high signal-to-noise ratio (SNR) and advancements in parallel imaging, such as GRAPPA. The name "parallel" comes from the fact that each coil element is measuring the signal from the patient's body. The number of phase encoding steps along the array coil can be reduced according to the acceleration factor, thus reducing the scan time. After the acquisition, the GRAPPA reconstruction estimates the missing k-space data based on information about the coil sensitivity distribution measured in the same object. The SNR in the accelerated scan will be less than that of the fully sampled MRI.
The SNR during parallel acquisition, SNR_{PA}, is influenced by both the degree of undersampling, described by the acceleration factor (R), and also by the g-factor (G), which is the local geometry



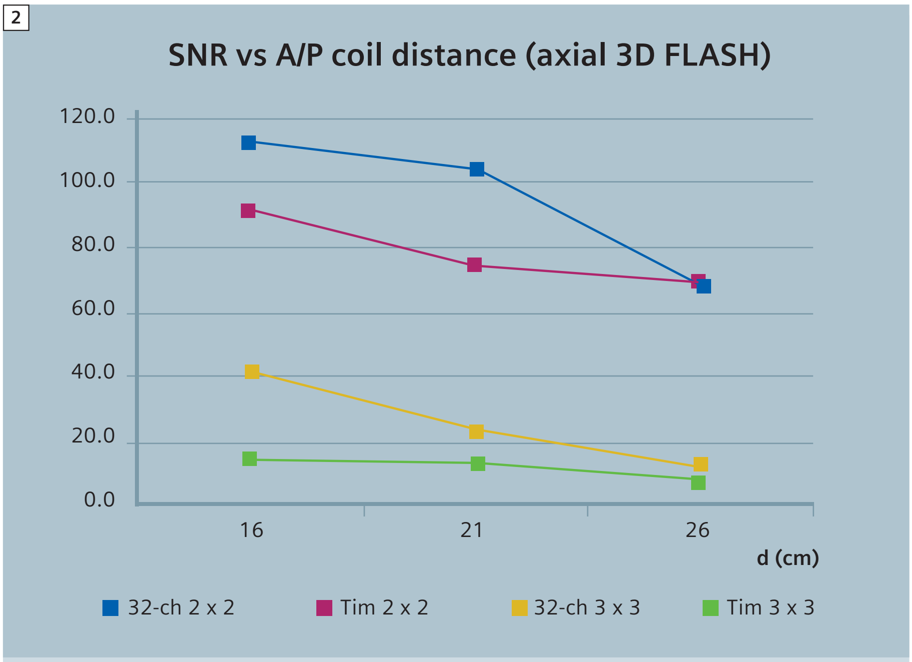
1 Schematic diagram of the phantom SNR experiment with the 32-channel coil and with the Tim Matrix coil. The center voxel of the interest is represented by the red cube inside the water phantom.

factor. SNR_{PA} is thus described by the following equation:

$$SNR_{PA} = \frac{SNR_{full}}{\sqrt{R*G}}$$

Simulations and experimental data have shown that G can be reduced, for a given acceleration factor and coil geometry, by increasing the field strength B_0 and/or by increasing the number of coil elements in a phased array coil. The use of multi-channel phased array coils with a high number of individual elements thus not only produces higher SNR values near the coil plane, but also decreases the SNR penalty associated with parallel imaging. We will demonstrate in this article how the 32-channel body array coil performs for accelerations of up to 4 in typical imaging techniques which are used for abdominal imaging.

2



2 SNR vs. A/P coil distance for 3D FLASH sequence with water phantom. The advantage of the 32-channel coil is decreasing with increasing distance between the anterior and posterior coil elements.

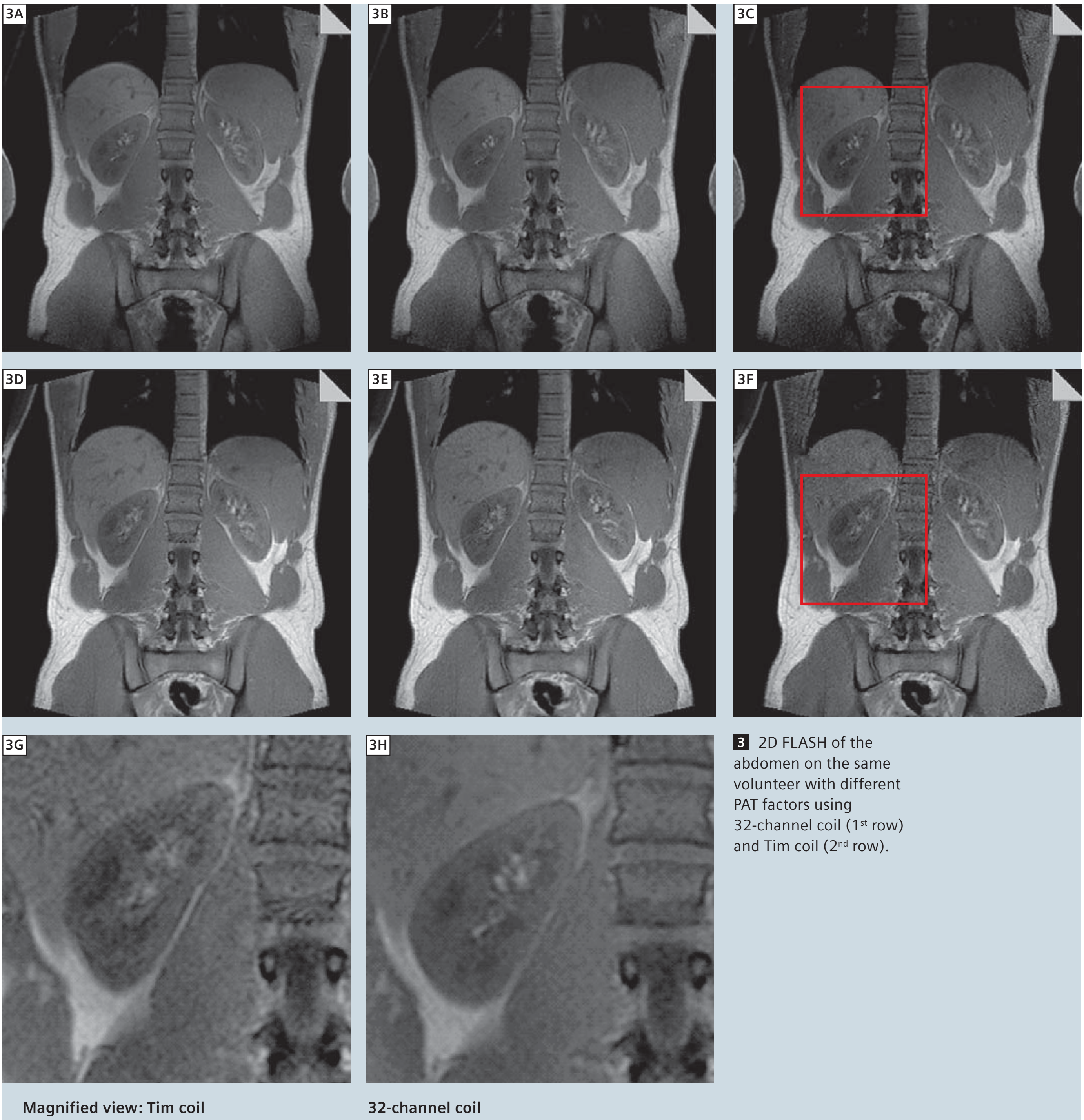
Method

In order to demonstrate the advantages of the 32-channel coil, the following experiments are performed. First, we compare the 32-channel coil performance with the standard Tim Matrix coil. A water phantom is scanned with the 3D FLASH sequence on MAGNETOM Trio, A Tim System using the 32-channel coil and the Tim Matrix coil for the SNR comparisons. The basic measurement is repeated 5 times, and SNR is calculated based on the mean and standard deviation of the same voxel at the center of the spherical water phantom (shown as a red voxel inside the water phantom in Fig. 1). The SNR values are compared for different acceleration factors and for the different coil A/P distance d (i.e. the distance from the coil surface to the center of the water phantom: will be measured at 16, 21, and 26 cm). Note that *d* is set equal distance from both anterior and posterior coils. See Fig.1 for the schematic diagram of the first experiment. Second, 2D FLASH coronal abdomen scans are performed on a volunteer using Tim and 32-channel coils. The 2D FLASH coronal abdomen scans are repeated with the different PAT acceleration factors applied in R/L direction.
Finally, the various clinical scans at abdomen/renal and pelvis regions are performed using the 32-channel coil to observe the quality of the images in a clinical situation.

Results

Phantom SNR experiment

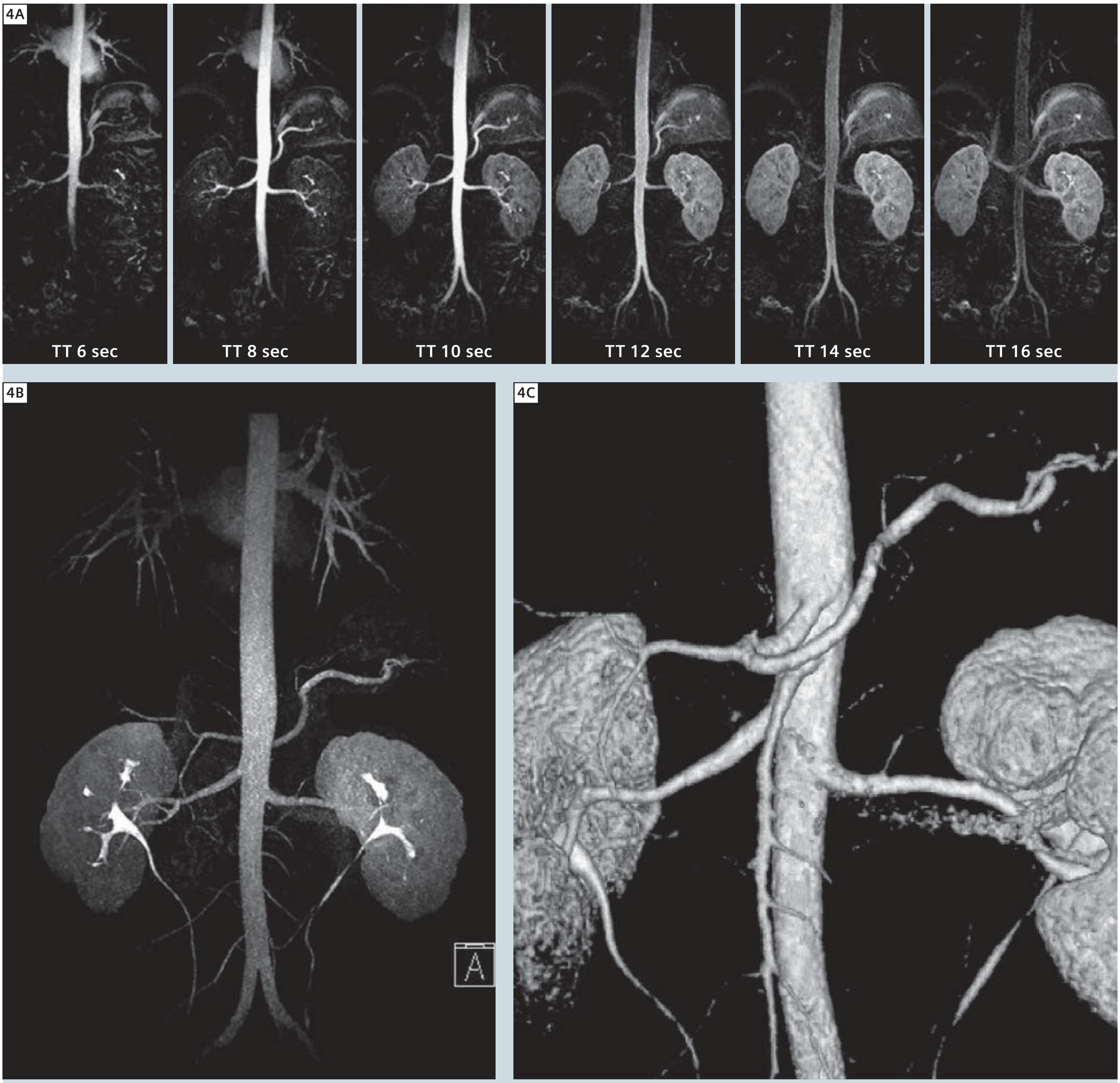
Fig. 2 shows the SNR vs. coil A/P distance plots for 32-channel and Tim coils with PAT acceleration factor of 2 x 2 and 3 x 3. In general, the PAT acceleration factor 2 x 2 has the superior SNR than 3 x 3 as expected. Note also, that the SNR drops with an increasing distance between the anterior and posterior coil elements. The 32-channel coil, however, drops faster than the Tim coil which is due to the smaller coil elements in the 32-channel coil. Smaller coil elements will help to improve the SNR for objects closer to the coil, but the signal drops faster when moving away from the coil. Overall, the 32-channel coil shows equal or the better SNR than the Tim coil in all cases, in particular with the cases with smaller *d*. In practice, however, the advantage of the 32-channel coil becomes more obvious when scanning thinner patients with an A-P distance of less than 25 cm.



3 2D FLASH of the abdomen on the same volunteer with different PAT factors using 32-channel coil (1st row) and Tim coil (2nd row).

Volunteer abdomen study with different PAT acceleration factors

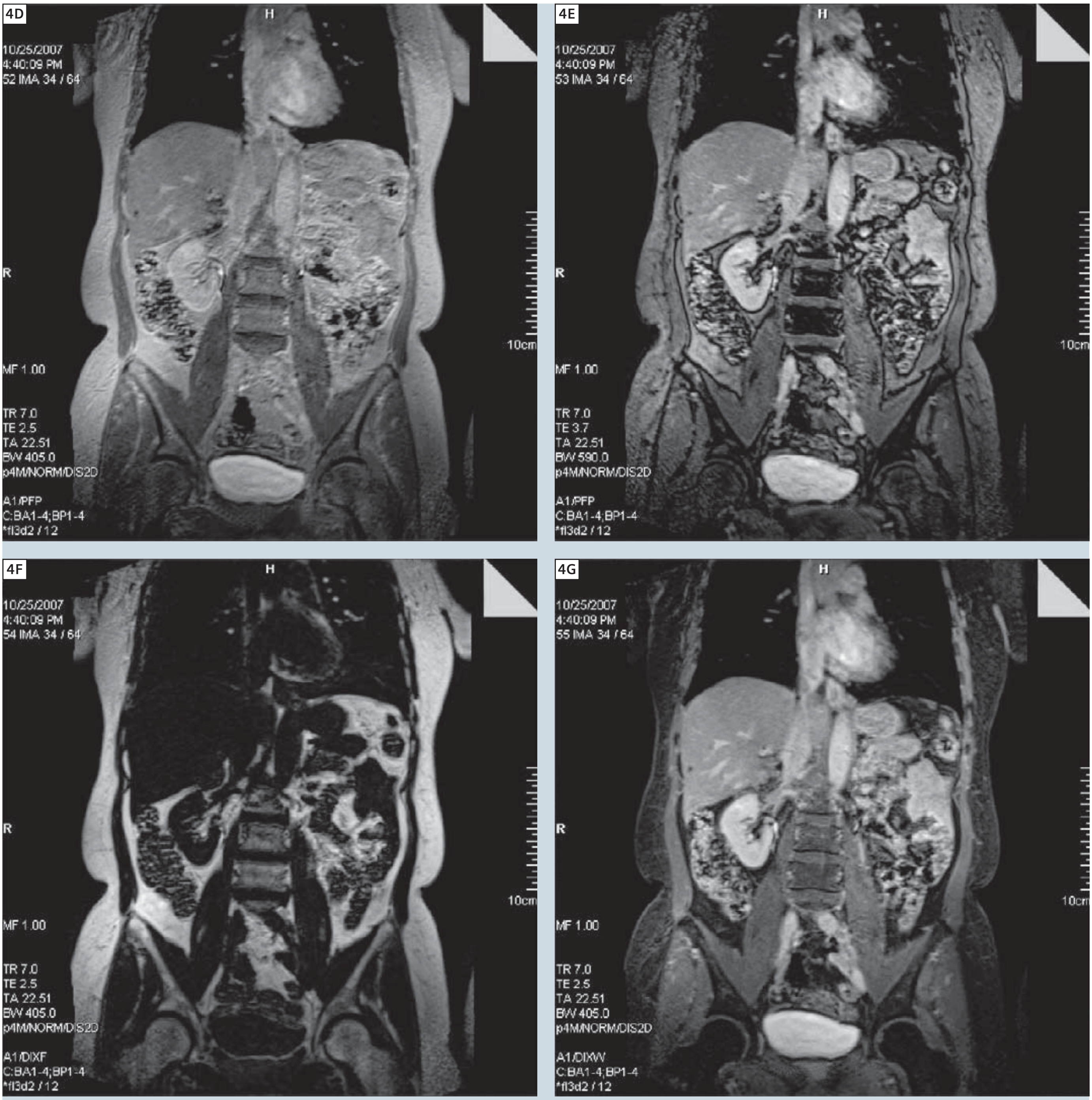
Fig. 3 shows FLASH 2D of the abdomen on the same volunteer with different PAT acceleration factors. In a coronal orientation the phase encoding direction is R/L. In the R/L direction, the Tim coil has three coil elements, while the 32-channel coil has four. As expected both coils show excellent image quality with acceleration factors of 2 and 3. For the PAT acceleration factor 4, the Tim coil starts to produce noisy images due to the underdetermined reconstruction, and the PAT related noise becomes apparent (highlighted by the boxes). The 32-channel coil retains the image quality throughout the PAT acceleration factor changes.



4 Clinical examples of MR images using 32-channel body array coil. The examples include **(A)** MIP of *syngo* TWIST dynamic MRA (4 time points with 4 second interval are shown), **(B)** MIP of high-resolution contrast-enhanced MR angiography (ceMRA) and **(C)** VRT of high-resolution ceMRA.

Clinical cases with 32-channel coil

Fig. 4 shows various examples of clinical cases using the 32-channel coil. The examples include 6 time points of the coronal dynamic contrast-enhanced MR Angiography (ceMRA - *syngo* TWIST) on abdomen (Fig. 4A), MIP of high resolution coronal ceMRA on abdomen (Fig. 4B), VRT of the high resolution ceMRA (Fig. 4C), and 4 different image contrasts generated by DIXON method on abdomen (Fig. 4D). Note that for the high-resolution ceMRA shown in Figs. 4B and C, the PAT acceleration factor 4 is applied in L/R direction, and this allows near-isotropic resolution (0.92 PE x 0.78 RO x 0.9 SS mm^3) within the single breath hold (22 seconds). For all cases in Fig. 4, the 32-channel coil produces exceptional image quality.



4 Clinical examples of MR images using 32-channel body array coil. **(D–G)** DIXON of abdomen.

Conclusions

In conclusion, the 32-channel body array coil shows excellent results, with better SNR and with improved image quality for the higher PAT acceleration factors in the left-right direction, particularly for slim patients when the distance between the anterior and posterior coil elements is less than 25 cm. The 32-channel coil is recommended for those who seek to utilize the maximum potential of MAGNETOM Trio, A Tim System for body MRI applications.

Contact
Yutaka Natsuaki, Ph.D.
Siemens Medical Solutions, Inc.
10945 Le Conte Avenue
Suite 3371
Los Angeles, CA, USA
yutaka.natsuaki@siemens.com