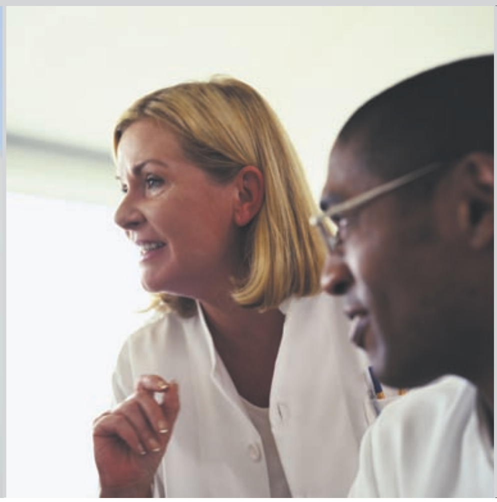
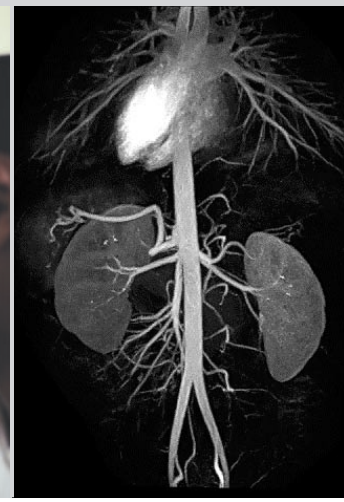
MRI Hot Topic





# Enhanced Diagnostic Versatility
## with Integrated Parallel Acquisition Techniques (iPAT) in MR-Angiography and Contrast-Enhanced MRA

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# Enhanced Diagnostic Versatility
## with Integrated Parallel Acquisition Techniques (iPAT) in MR-Angiography and Contrast-Enhanced MRA

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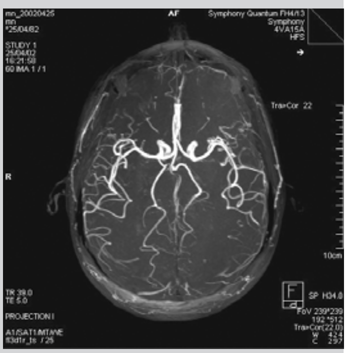
[1]
*Conventional MRA (TA = 5:26)*



[2]
*MRA with mSENSE (iPAT x 2) (TA = 3:09)*

*These images were obtained on a Siemens Symphony Quantum using an MRI Devices 8-channel head array coil that is compatible with the Siemens implementation of iPAT.*

[3]
*512 matrix with 80 partitions (voxel dimensions: 1.3 x 0.8 x 1.8 mm), (TA = 19 s)*

## Introduction

MR-Angiography (MRA), and more recently Contrast-Enhanced MR-Angiography (CE-MRA), are well-established methods of evaluating vascular structures and can be used literally from head to toe. Standard Time-of-Flight (ToF) techniques are used in neurological studies; CE-MRA and ToF are used to image the carotids, the aorta, the pulmonary and the renal arteries, and the vasculature in the extremities (peripheral angiography).

Standard ToF neuro angiography is well known for evaluating pathology in the brain, where the contrast to noise is quite good since flowing spins are unsaturated (bright) against a saturated background brain tissue signal. This high intrinsic contrast to noise makes it particularly well suited to iPAT, wherein imaging times can be significantly reduced.

CE-MRA, which has revolutionized almost all standard all MR-Angiography techniques, is also particularly well suited for iPAT due to its high intrinsic contrast to noise ratio. However, there are several ways in which iPAT can be implemented, and these new techniques need to be judiciously matched to the appropriate clinical applications in order to obtain optimal results.

## Methods

There are two parallel acquisition strategies in the Siemens implementation of iPAT, making it the most comprehensive parallel imaging solution on the market. While both require integrated panoramic coils for obtaining the multiple data sets used to reduce scan time, each technique has its own particular strengths relative to specific clinical applications. These methods are best understood in terms of how they combine the individual coil data sets to generate the final "reconstructed" image. It is important to understand that all MR images are reconstructed from raw data that is Fourier-transformed into image data. In order to implement any iPAT method to speed up this process, data for multiple coils must be combined to generate the final image.

Modified Sensitivity Encoding (mSENSE) combines the multiple data sets obtained from individual coils after the raw data is Fourier-transformed into individual image sets [1]. The second strategy, GeneRalized Autocalibrating Partially Parallel Acquisitions (GRAPPA), combines individual coil raw data before a Fourier-transform is applied to produce the final reconstructed image [2] [3]. Due to these subtle reconstruction differences, it can be shown that some imaging tasks are best suited to mSENSE while others are more appropriately performed with GRAPPA.

**References**

**[1]** Klaas P. Pruessmann, Markus Weigner, Markus B. Scheidegger, and Peter Boesiger. SENSE: Sensitivity Encoding for Fast MRI. Magnetic Resonance in Medicine 42: 952-962, 1999.

**[2]** D. K. Sodickson, W. J. Manning. Simultaneous Acquisition of Spatial Harmonics (SMASH): Fast Imaging with Radiofrequency Coil Arrays. Magnetic Resonance in Medicine 38: 591-603, 1997.

**[3]** Mark Griswold, Peter Jakob, Robin Heidemann, Mathias Nittka, Jiamin Wang, Berthold Kiefer, Axel Haase. Push-button PPA Reconstructions: GeneRalized Autocalibrating Partially Parallel Acquisitions (GRAPPA). Proc. Intl. Soc. Mag. Reson. Med. 9, 2001.

## Results

### ToF Angiography with mSENSE

With mSENSE, fold-over can be an issue; however, for most neuro applications, this has never been a significant problem as the anatomy easily conforms to standard matrix and FoV applications. The first implementations of GRAPPA (conceptually similar to SMASH) were limited to linear arrays of coils, and typical neuro anatomy was not suited to this coil design. However, mSENSE reconstruction techniques could easily use arbitrary coil configurations. Here we show how mSENSE can provide high quality neuro angiograms in a significantly reduced scan time using an 8-channel head array coil [1] [2].

### CE Abdominal MR-Angiography with GRAPPA

In other applications, GRAPPA is the technique of choice, because its reconstruction algorithm is more robust for anatomy where wrap or fold-over artifacts are of concern. With a 6-channel body array coil*, we can phase-encode left to right in a linear fashion, therefore we can use GRAPPA without worrying about significant wrap-around artifacts. This MIP image [3] was obtained at the University of Essen (Germany) on a Siemens Sonata equipped with two 6-channel array coils and using GRAPPA with an iPAT factor of 2 (acquisition time: only 19 s). The 3D data set consists of 80 partitions; using 24 ml of Magnevist, the signal to noise is quite good, with no wrapping artifacts.

### CE Peripheral MR-Angiography with GRAPPA

In peripheral angiography, GRAPPA is also the technique of choice, because its reconstruction algorithm is more appropriate for linear arrays of coils.

[4] shows a 3-station MRA with varying iPAT factors while [5] shows a 4-station MRA (iPAT x 2). Both studies were performed using the Siemens IPA (integrated panoramic array) concept. IPA allows for a one-time, simultaneous placement of multiple coils at the beginning of the examination. The system then automatically moves the table between stations, and activates the appropriate coil(s) for each acquisition. The combination of iPAT and IPA can dramatically reduce the total time required to perform a multi-station MR examination.

## Conclusion

Integrated parallel acquisition techniques (iPAT) can significantly reduce imaging time when there is sufficient intrinsic contrast to noise, or they can improve spatial resolution for techniques that are bounded by time constraints (e. g. breath-hold imaging).

There are two basic techniques for iPAT: mSENSE, which is best suited for arbitrary coil geometries; and GRAPPA, which is best suited for applications where coil configurations are not limited by over-folding. Together, these techniques offer a comprehensive parallel imaging solution, for maximum flexibility.

IPAT is available on Maestro class systems running *syngo* 2002B.

*[4]*
*3-station MRA. Aortic arch to iliac arteries: 384 matrix, TA = 14 s (GRAPPA x 3) Upper legs: 512 matrix. TA = 11 s (GRAPPA x 2) Lower legs: 512 matrix. TA = 40 s (no iPAT)*

*[5]*
*4-station MRA with GRAPPA x 2 for each station (256 matrix). Acquisition times (per station): Pelvis: 8 s; Upper leg: 7 s; Midleg: 7 s; Lower leg: 7 s*

* The information about this product is being provided for planning purposes. The product requires 510 (k) review and is not commercially available in the US.

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