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The MAGNETOM Flash

Newsletter for Siemens MAGNETOM Users

IN THIS ISSUE...

From the Editor

The MAGNETOM Flash newsletter continues to broaden its scope to meet your professional needs. Anticipating the certification examinations facing MRI technologists within the next two years, this issue of the FLASH provides a list of resources which includes textbooks, review workbooks, and training courses. Also included in this issue is a feature article focusing upon perfusion imaging with MRI. Announced within this issue are upcoming meetings and seminars. And, as usual there is a section for applications tips and protocols from Siemens applications specialists and from you, our users.

If your MRI supervisor has not received previous issues of the FLASH and shared them among all your technical staff, contact me for additional back issues. Since this is your newsletter, please continue to contribute articles, announcements, interesting cases, questions, comments, etc.

Gary R. McNeal, Editor

THE MAGNETOM Flash

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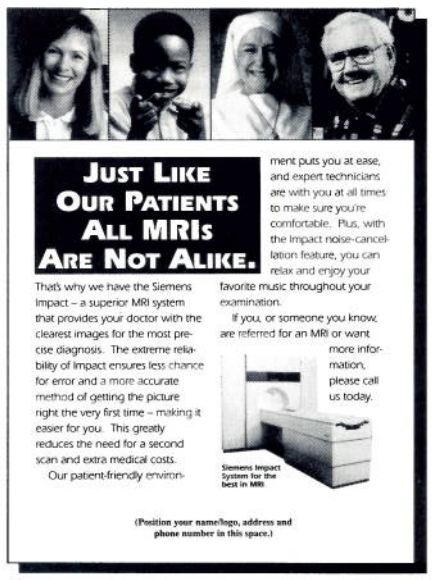
Marketing Enhancements

Advertisements are now available from Siemens to announce your new MR system!! These ads are ideal to promote your facility and effectively high-light the main features of your new system. The ads are directed toward the community and simply communicate why all systems and facilities are not alike. They then ask anyone referred for an MR to call for information prior to scheduling an exam. Designed for newspaper use in a 65-line screen and offered in two sizes, the ads may be placed in the medical section of local newspapers. All ads have an area designated to place your name/logo, address, and phone number. The ad slicks are sold individually for $25 - just call (800)334-4066 and indicate the appropriate order number. To have your ad personalized or re-screened for magazine use, call O'Sullivan Advertising/Public Relations, Inc., at (201)267-1440.

MRM804 3 column by 9"
MRM805 2 column by 6"



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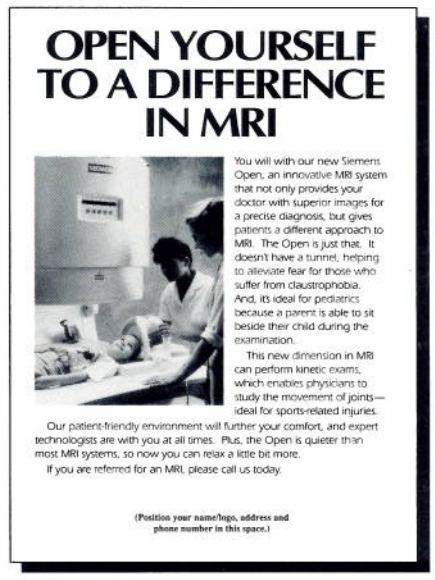

MRM802 3 column by 9"
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Seminars and Meetings

For additional information on any of the above meetings or to include a meeting announcement in our next issue of the FLASH, please contact Michele McDonald (MR Applications Group) at phone number (908)321-3270.

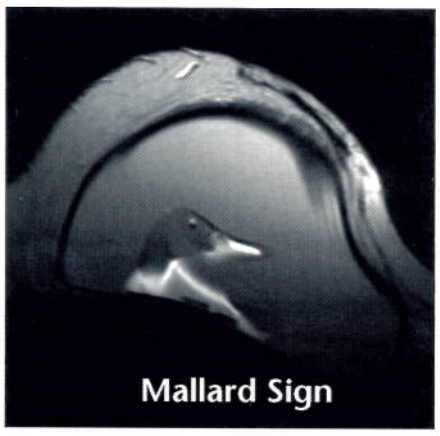
Sept 12-16	MRI Essentials for Technologists, Hyatt Regency, New Brunswick, NJ
Sept 29 - Oct 2	6th Annual Advances in Mid & Low Field MRI, Disney World, FL
Oct 8-9	An Interventional MRI Workshop, Boston, MA
Oct 10-12	Clinical MRI, New York University Medical Center, Dept. of Radiology, NY, NY
Oct 13-15	SMR Workshop on Cardiovascular MRI: Present and Future, Santa Fe, NM
Oct 13-16	8th Annual Bill Bradley & David Stark Practical MRI, New York, NY
Oct 20-22	Siemens MR Technologists Seminar, Toronto, Canada
Oct 24-28	MRI Essentials for Technologists, Hyatt Regency, New Brunswick, NJ
Oct 27-30	Economics of Diagnostic Imaging 1994 National Symposium, Washington, DC
Nov 16-19	5th Annual Advanced MRI for Technologists, Orlando, FL
Dec 12-17	13th Annual CT/MRI Head to Toe, New York University Medical Center, Dept. of Radiology, NY, NY
Feb 18-25, 1995	MRI in Clinical Practice, Breckenridge, CO

Announcements: New Coils & Software

HURRAY!!! Siemens is pleased to announce commercial availability of the following new coils and software upgrades for the MAGNETOM Impact and Vision systems. For the Impact, **A22A** software will be deliverable in October 1994 and will offer the STUDY/DISPLAY feature which allows slices to be displayed on their scout image with corresponding slice numbers. A22A will also change the horizontal axis on the MEAN/CURVE to units of time rather than image number and it will provide support for the new flex coils typically used for advanced orthopedic imaging. The **Power Package 2 option,** deliverable for the Impact in November 1994, will provide additional RAM memory (288 MB), a larger hard disk (2.1 GB) which can store up to 9000 images, the same host computer as in the Vision (Spark 10), and the same image reconstruction array processor as in the Vision. The Power Package 2 option will allow realtime image reconstruction/postprocessing and will allow the Impact to support the new array coils. The **Body Array Coil,** deliverable in November 1994, consists of four elements (2 anterior and 2 posterior) which are used together to increase the signal-to-noise ratio (snr) of body images as compared to the standard body coil. Thus, this snr gain can be utilized to image with a smaller FOV to improve spatial resolution as compared to the standard body coil. The **Spine Array Coil,** deliverable in November 1994, consists of six elements (superior to inferior) which are used in sets of four to image over larger areas of coverage at higher snr as compared to smaller surface coils over smaller areas of coverage. Contact your local Siemens representative for details and pricing.

Interesting Case: Mallard Sign

This case was submitted by Kevin Johnson, Research Technologist, of Abbott Northwestern, Minneapolis, MN. The image to the right demonstrates an interesting anomaly which was discovered during a routine breast examination.



MRI Resources: Registry Review

The MRI Registry Review Program™ offered by Medical Imaging Consultants, Inc. is an innovative interactive correspondence program consisting of twelve progressive course modules. Each of the twelve modules focuses on a separate topic, and contains 15-25 pages of text as well as an abundance of graphics, illustrations and images. 40 thought-provoking questions conclude each module. The course format allows you to study at your own pace, when and where it is convenient for you. The modules have been designed to strictly adhere to the ARRT Content Specifications for the Examination in MRI. Each module is designed to provide two ASRT-accredited category A continuing education credits so that you can earn up to twenty-four continuing education credits upon completion of the program. The registry exam is not manufacturer-specific and does not use manufacturer-specific terminology. This MRI Registry Review Program also does not use manufacturer-specific terminology. For further information, contact Philip A. Femano, Ph.D. at Medical Imaging Consultants, Inc., phone number (201)812-1122.

Applications Tips

Apps Girl

☑ Vision	☑ IMPACT
☑ SP	☑ OPEN

She was just a little depressed… no FLASH, no NEX in her life. But, something was just beginning to STIR inside her. She was missing the right MR. It was time for a REAL ACQUISITION. Nothing IMAGINARY for her. She wanted to turn her life around. She wanted someone who knew how to DESS. Someone who drove a QUADRATURE HELICON SP4000 in a HASTE. Someone who was FAST, but knew how to CISS. She also did not want someone who would ALIAS all over town. She did not want PREP-PULSES anymore, she wanted a REAL GMR. She wanted VELOCITY and ACCELERATION in her life, not a JERK. She tried one after another… a MIP, then an MPR, and finally even an SPGR, but nothing much happened. Oh maybe a HALF-NEX here, or a SINGLE-VOXEL-SPECT there. She said "I'm spending too much time SHIMMING, if you know what I mean." Some were complete ZERO-FILLS. One even flew off in an MPRAGE. She was starting to get a little IR'd. She pondered, "Maybe I need a TRANSMITTER-ADJUSTMENT?" She admitted to herself, honestly, "A little FAT-SUPPRESSION here and there wouldn't hurt, either." Finally she realized, "NETWORKING... now that's the ticket!"

Fiction by Elena Rose.

Cellular Phones

☑ Vision	☑ IMPACT
☑ SP	☑ OPEN

Some cases of possible RF interference from cellular phones have been reported by mobile MAGNETOM users. In one case, the MAGNETOM experienced computer errors during ramp-down while a cellular phone was used inside the computer room. In another case, the oxygen alarm went off and the patient door automatically rolled up when a cellular phone was used inside the control room. These are the only two reported cases of possible RF interference from cellular phones. Other such cases may have also occurred at other sites, but were not recognized or reported. If this happens at your site, please contact Siemens service immediately.

Cervical Pads

☑ Vision	☑ IMPACT
☑ SP	☑ OPEN

When using the Siemens HH Neck Coil, extra padding may be placed under the curvature of the neck and under the back of the head to improve patient comfort, support, and stability. Many technologists cut a piece of "egg-crate" foam into a 4 inch by 12 inch rectangle (about 1 inch thick), then fold about 2 inches of one end over upon itself and tape it permanently so. They position the folded, double-thickness portion under the curvature of the patient's neck and position the single-thickness portion under the back of the patient's head. This extra pad is used in addition to the standard pads provided for the neck or head coils.

Combine/Arrange

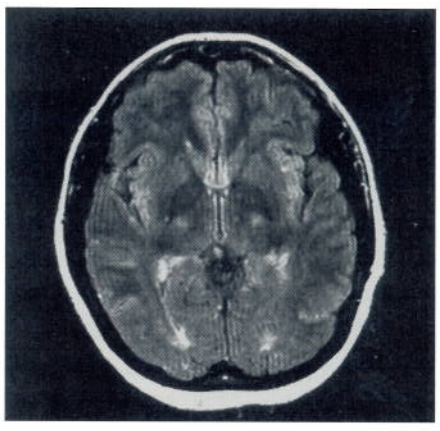
☐ Vision	☑ IMPACT
☑ SP	☐ OPEN

It is often desirable to combine multiple studies into one new study with anatomical sorting, i.e., when using an interleaved gap & fill technique for liver imaging. For the MAGNETOM SP systems refer to sections G.1.4.6 and G.1.4.7 of the NUMARIS A2.7 operators manual, or for the MAGNETOM Impact system refer to sections D.3 and D.4 of the NUMARIS A2.1 operators manual. To combine multiple studies into one new study on the **SP** system: first you must select DISPLAY/STUDY/COMBINE, toggle on the original studies from the list, enter any name for the new study to be created, wait for the new study to be created, and finally EXIT. To anatomically sort this new combined study: select DISPLAY/STUDY/ARRANGE, toggle on the new study from the list, setup SORTING: ANATOMICAL, and finally EXIT. However, to combine multiple studies into one new study on the **Impact** system: select STUDY/CREATE, enter any name for the new study to be created, select QUERY to get the patient/study list, toggle on the original studies from the list, hit GO, hit GO again, wait for new study to be created, and finally EXIT. To anatomically sort this new combined study: select STUDY/ARRANGE, then setup MODE: SINGLE and ARRANGE: ANATOMICAL, select QUERY to get the patient/study list, toggle the new study, hit GO, hit GO again, and finally EXIT. After the sorting is complete you are free to film or post-process the new study as usual.

FLAIR Technique

☑ Vision	☑ IMPACT
☐ SP	☐ OPEN

The Fluid Attenuated Inversion Recovery (FLAIR) technique may be used to suppress signal from long T2 tissues (fluids). On the MAGNETOM Impact or Vision systems this is done with any sequence containing the designation _ild_ within the sequence name. It has been suggested that, by suppressing the CSF signal of the ventricles in a T2-weighted brain exam, small periventricular white matter lesions may be better appreciated. Also, the FLAIR technique might be used to suppress the water signal in breast imaging. This technique is similar to the Short Tau Inversion Recovery (STIR) technique except that the Inversion Time (TI) is optimized to null fluid rather than to null fat. Since the T1 value of fluid is much longer than the T1 value of fat, the optimal TI to suppress fluid (1800-2000 ms) is much longer than the optimal TI to suppress fat (120-150 ms). As a consequence, a special form of the Inversion Recovery sequence is utilized, with slices being interleaved within the long TI. On the MAGNETOM Impact or Vision systems, this is done with any inversion recovery sequence containing the designation _ild_ within the sequence name. The sequence designation _ild_ means interleaved. For example, the following (turbo) protocol has been optimized for FLAIR imaging on an Impact configured with both the Power Package option and the Advanced TurboSE software option: tirm15_ild_150b130.wfa, tr 6000, te 150, ti 2000, fov 230, matrix 210x256 oversampled, 2 acquisitions, 8 slices, 5 mm thick, 100% gap & fill, swap phase/readout, no filter, time 2:54 min. However, if your Impact does not have both of the options listed above, you may use the following (conventional) protocol: irabs_ild_20b130.ufa, tr 5000, te 110, ti 2000, fov 230, matrix 192x256 oversampled with Half Fourier, 1 acquisition, 15 slices, 5 mm thick, 20% gap, swap phase/readout, no filter, time 8:40 min.



TurboSE FLAIR head.

Minimum FOV

☑ Vision	☑ IMPACT
☑ SP	☑ OPEN

To determine the minimum FOV required to allow a 512 matrix: look at the minimum FOV with a 256 matrix selected, and then double that FOV. This must be done before selecting a 512 acquisition matrix.

A2.7 Contest Winner

Congratulations to the winner of the A2.7 contest drawing. Diane Backer, R.T., of Robert Packer Hospital in Sayre, PA, has won an expense-paid trip to the next Siemens MR Technologist Seminar in Toronto, Canada.

FEATURE ARTICLE: Assessment of Solid Organ Perfusion in the Thorax and Upper Abdomen Using Contrast-Enhanced MR Imaging

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Department of Radiological Sciences
Deaconess Hospital and Harvard Medical School, Boston, MA

Introduction

It must be remembered that, at the time of writing, perfusion imaging is still a research technique and has yet to be validated in clinical practice. The protocols described below should be regarded as strictly research tools and not used as the basis for clinical decision making. In addition, the indicated protocols and sequence parameters may not be available on all MAGNETOM system configurations.

The idea of obtaining functional perfusion data from MRI is not new. Even in the earliest days of MR imaging it was recognized that T1- and T2-weighted contrast alone did not provide a sufficiently specific means of characterizing diseased tissue. However, it is only recently, with the advent of fast scanning methods and the availability of safe contrast agents, that perfusion MRI has become reliable and practicable for tissue characterization. Perhaps the potentially most useful applications of MR perfusion imaging (outside the head) are in the heart and kidneys. Methods of noninvasive diagnosis and assessment of myocardial ischemia are becoming increasingly important as more treatment options become available for this common life-threatening condition. Many studies have shown that selective coronary arteriography does not provide all the information required when assessing the severity of myocardial ischemia and has important limitations in terms of safety and cost. However, established isotope techniques also have drawbacks in the form of poor spatial resolution, susceptibility to artifact and a wide range of sensitivity and specificity. Echocardiographic myocardial perfusion techniques remain experimental. To date the MR techniques described for evaluating myocardial ischemia have had limited clinical utility when used alone. At rest myocardial MR perfusion imaging lacks sufficient sensitivity and specificity. Pharmacological stress MR perfusion imaging of the myocardium produces a study similar to isotope perfusion techniques, and additionally may allow evaluation of the cardiac output. Pharmacologic stress has also been used with MR ventriculography to evaluate the functional effects of myocardial ischemia but also has limitations when used alone. We assessed the feasibility of a combined fast MR perfusion and MR ventriculography imaging technique before and during pharmacologically induced stress. This provided information on both regional perfusion/reperfusion, ventricular function, and cardiac output with good correlation as compared with scintigraphy (hybrid Thallium-Technetium SestaMIBI) and coronary arteriography.

In the kidney MR perfusion imaging promises to yield similar data on differential perfusion to that currently provided by nuclear medicine techniques, only with higher spatial and temporal resolution and without using ionizing radiation. As with isotope renography the information gained may be enhanced by the use of pharmacological agents such as ACE inhibitors (as in captopril renography). In combination with MR Angiography this could provide a "one-stop-shop" in the assessment of suspected renovascular hypertension (RVH) and living donors for renal transplants.

Similar considerations apply to MR perfusion imaging of the other solid organs in the abdomen. In the liver first pass perfusion imaging can help in the characterization of malignant lesions and assessment of response to therapy (e.g. after chemoembolization). Furthermore this is easily combined with MR portal venography to aid in the planning of hepatic surgical/interventional procedures. In the pancreas this technique may prove to be useful in evaluating acute pancreatitis both in diagnosis (where it may be more sensitive than CT) and in providing information on differential perfusion and viability of different anatomical parts. Dynamic perfusion also aids in the diagnosis of hypervascular islet cell tumors. Perfusion imaging can help characterize adrenal masses and splenic perfusion patterns can indicate underlying pathology.

Protocols for Cardiac MR Perfusion Imaging

The details of this protocol have been carefully thought out to maximize the information obtained. For example, the use of two slice short axis views and acquiring the ventriculograms in two different views increases the volume examined and reduces the risk of sampling error. Also, endocardial definition is improved on the cine MRA by acquiring the ventriculograms after the gadolinium enhanced MR perfusion images. The order of image acquisition is as follows:

1. Sagittal scout
2. Axial multislice T1 spin echo
3. RAO equivalent single slice TurboFLASH scout
4. Gadolinium contrast bolus during…
5. Short axis two slice TurboFLASH perfusion (RESTING)
6. RAO equivalent single slice FLASH2D ventriculography (RESTING)
7. Short axis two slice FLASH2D ventriculography (RESTING)
8. Dipyridamole infusion
9. Gadolinium contrast bolus during…
10. Short axis two slice TurboFLASH perfusion (STRESSED)
11. RAO equivalent single slice FLASH2D ventriculography (STRESSED)
12. Short axis two slice FLASH2D ventriculography (STRESSED)

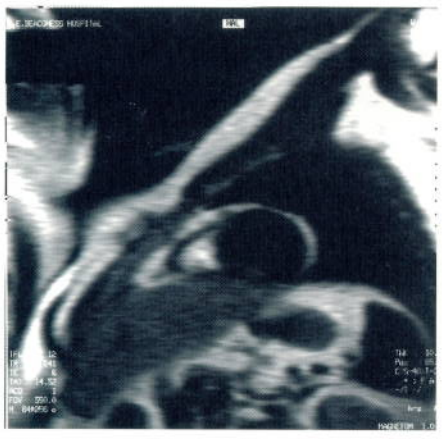


Figure 1. Short axis TurboFLASH shows arrival of gadolinium bolus in right ventricle. Before arrival of gadolinium bolus in left heart the myocardial signal is nulled by the short TI.

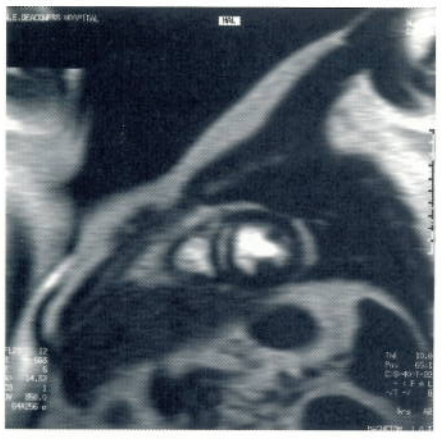


Figure 2. Resting short axis TurboFLASH shows arrival of gadolinium bolus in left ventricle and early enhancement of the interventricular septum.

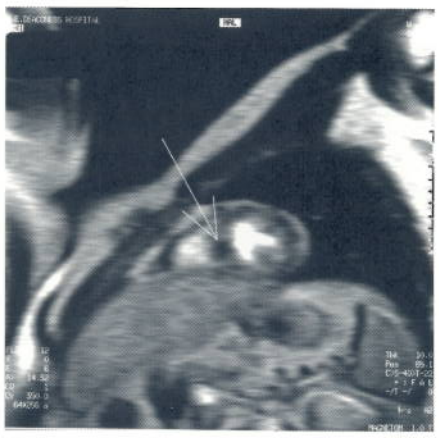


Figure 3. Stress (post dipyridamole) short axis TurboFLASH shows area of low signal in interventricular septum indicating perfusion defect due to left anterior descending stenosis (arrow).

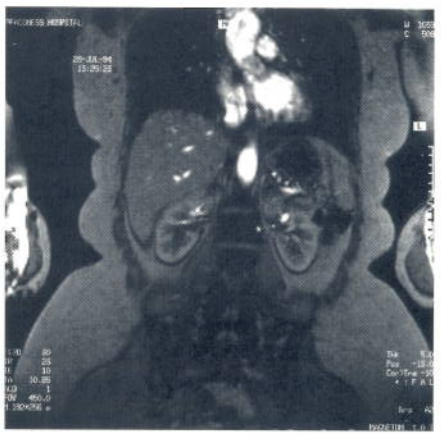


Figure 4. Oblique coronal FLASH2D image of kidneys before gadolinium enhancement.

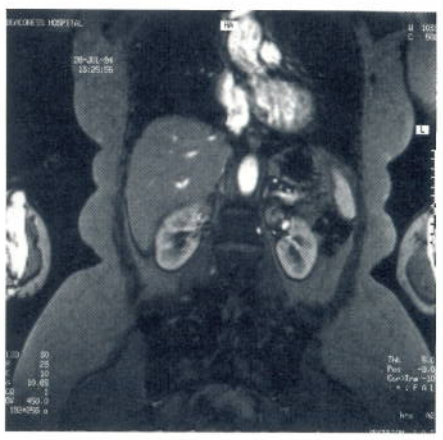


Figure 5. Oblique coronal FLASH2D image in same position after gadolinium shows equal enhancement of both kidneys. Note improved corticomedullary differentiation reflecting greater perfusion of cortex initially (normal).

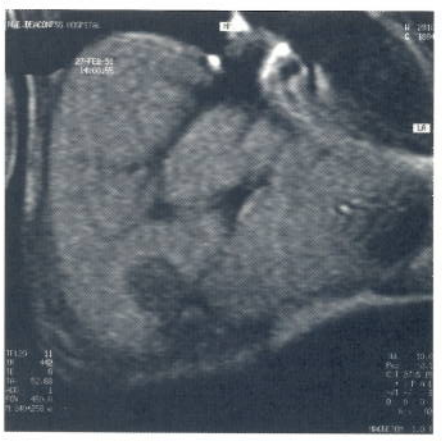


Figure 6. Oblique coronal TurboFLASH image of liver before gadolinium enhancement shows low signal from hepatoma.

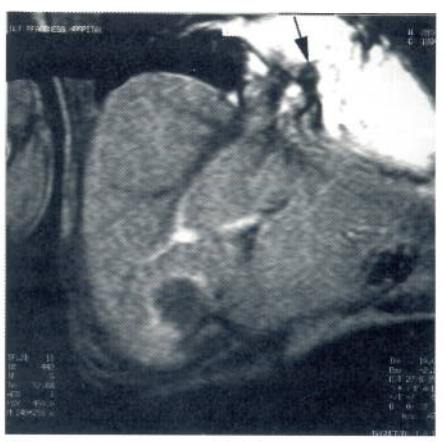


Figure 7. Oblique coronal TurboFLASH image in same position after gadolinium shows enhancement of portal veins and peripheral enhancement around hepatoma. There is no enhancement of the main mass of this relatively low vascularity hepatoma. Coincidental finding of atrial mixoma is noted in left atrium (arrow).

Techniques for Cardiac MR Perfusion Imaging

The usual patient screening for MRI should be used to exclude patients with metallic implants and other general contraindications to MRI. In preparation for pharmacological stress using dipyrimidol, the patient should refrain from foods, drinks and drugs containing xanthines (e.g. theophylline, caffeine in coffee etc.) for 24 hrs prior to the examination. This is the same as for persantine stress scintigraphy and, thus, patient information leaflets on this topic should be readily available from nuclear medicine departments. Upon the patient's arrival at the MR suite the procedure is explained and the patient is prepared with the placement of a peripheral 19G intravenous cannula for contrast infusion. Once the patient is in the scan room ECG electrodes are placed on the patient's back for cardiac gating and pulse oximeter and BP monitoring devices are attached. If the patient is not in sinus rhythm (e.g. they are in atrial fibrillation) or has uncontrolled tachycardia, then serious consideration should be given to abandoning the study as images will be seriously degraded. Once a good ECG trace is obtained the study can proceed. As with cardiac nuclear medicine studies, patients must be monitored throughout the stress examination with continuous ECG, pulse oximetry, along with BP every minute during and after the dipyridamole infusion. All monitoring equipment must be effective even

when the patient is in the magnet, and facilities for resuscitation must be readily available as well. The patient is instructed regarding the breathhold technique for those sequences that require it, with emphasis on the need for a consistent pattern. Repeated small inspiratory breathholds are suggested and have proved reliable, though the alternative of an end-expiratory breathhold technique is equally satisfactory. Imaging can be carried out using the body coil alone; however, a quadrature phased array coil gives superior results if available. The patient is placed in the bore of the magnet supine and head first, centering on the lower sternum. After acquiring a standard sagittal chest scout view, contiguous axial ECG gated T1-weighted images of the heart are acquired (SE_30DB130 sequence, 6 mm slice thickness, 0.2 distance factor, 350 mm FOV, 128x256 matrix, 3 acquisitions, TR set 100-150 ms less than the shortest R-R interval) to give an overview of anatomy and allow precise placement of subsequent slices. An axial image through the center of the left ventricle is selected as a localizer and a single TurboFLASH slice is positioned obliquely to pass through the apex of the LV and the middle of the mitral valve. This provides an RAO equivalent slice from which both the biplanar ventriculograms and short axis perfusion studies can be positioned.

Cardiac MR perfusion images are obtained with an ECG gated alternating two-slice TurboFLASH acquisition in the short axis orientation during quiet respiration. Acquiring images at two levels increases the area imaged and reduces the likelihood of sampling errors. The two slices are acquired alternately after every second R-wave with an interslice gap of 1.0 to 1.5 cm, located through the center of and perpendicular to the long axis of the left ventricle, as positioned from the RAO equivalent scout. Images are acquired during a bolus injection of contrast agent, both before and after pharmacological stress. In our institution, typical imaging parameters for perfusion TurboFLASH imaging at 1.0 Tesla are TR=12 ms, TE=6 ms, TI=100 ms, flip angle=12°, acq=1, FOV=350 mm, slice thickness=10 mm, matrix=64x256 interpolated to 256x256 (figures 1-3). The TI should be varied around 100 ms to maximize the nulling of the unenhanced myocardial signal and, if time allows, it should be optimized again for the post-stress images. If available, a sequence with TR= 6 ms, TE=3 ms may be used to improve temporal resolution. Images are acquired during every other R-R interval to allow full T1 relaxation. Thus, the time interval between each image acquisition at each location will be exactly four R-R intervals, or approximately 3-4 seconds. Image acquisition is started immediately following the injection of contrast material. Acquisition of a total of 48 images (24 measurements of 2 slices) takes about 1.5 minutes after the injection. Contrast enhancement is performed with gadopentate dimeglumine (Magnevist, Berlex, Wayne NJ), or equivalent, in a dose of 0.04 mmol/kg given as a fast IV bolus followed by a flush of 20 ml saline injected as fast as possible via the peripheral 19G cannula. Stress is achieved by an infusion of dipyridamole (0.56 mg/kg) given over 4 minutes with careful attention paid to physiological monitoring. Four minutes after completion of the infusion, post-stress MR perfusion images are obtained. The effects of dipyridamole can be reversed by slow infusion of aminophylline.

Techniques for Cardiac MR Ventriculography

The cardiac MR ventriculography exam (wall motion study) is accomplished with biplanar conventional gradient echo cine acquisitions in the RAO equivalent and the short axis orientations during quiet respiration. The single slice RAO equivalent cine is acquired in the same orientation and location as the TurboFLASH scout described above. The two slice short-axis cine is acquired in the same orientation and locations as the TurboFLASH perfusion scan described above. Identical positions are used before and during pharmacologically induced stress. Typical imaging parameters for the alternating two-slice FLASH2D sequence are TR=25-30 ms per slice, TE=10-12 ms, flip angle=30°, acq=2, matrix=160x256, FOV=350-400 mm, slice thickness=5 mm, gap=200%, and number of cardiac phases= 12-16. Typical imaging time for each cine acquisition will be approximately 4 minutes, dependent on R-R interval. In suitable candidates who can reliably breathhold and have a resting heart rate of 60-70 bpm (i.e. no tachycardia) there is an alternative possibility of gaining this cine information as breathhold segmented-k space cine TurboFLASH acquisitions.

Clinical Interpretation of Cardiac MR Perfusion and Ventriculography

The MR perfusion and ventriculography exams can be reviewed either as individual images or, more usefully, as cine loops. On MR perfusion images, areas that enhance equally during rest and during stress are considered normal while those areas that do not enhance or show delayed enhancement are either ischemic or infarcted. Areas that enhance promptly during rest but not during stress are considered reversibly ischemic (similar to a nuclear medicine study). Similarly, when assessing MR ventriculograms, areas that are hypokinetic or dyskinetic during rest and during stress are severely ischemic or infarcted while those areas that have normal motion during rest but develop motion abnormalities during stress are reversibly ischemic. Correlation of the two studies provides more accurate information than either one alone. More quantitative information about perfusion may be obtained by comparing the signal intensities of specific myocardial segments (ROIs) to the signal intensity of the chest wall musculature (e.g. pectoralis). Graphs of signal intensity vs. time (TSCs) can be plotted for each myocardial segment. We prefer to perform these analyses on a Macintosh Quadra workstation using the public domain software called NIH Image (available from the Internet by anonymous ftp from zippy.nimh.nih.gov, or available on floppy disk from NTIS, 5285 Port Royal Rd., Springfield, VA 22161, part number PB93-504868) along with graphing, statistics and spreadsheet programs. Using ROIs in the right and left ventricles to generate blood pool TSCs, changes in cardiac output can also be measured, e.g., with an indicator dilution curve model.

Techniques for Renal MR Perfusion Imaging

For renal MR perfusion imaging, a similar strategy is employed with contrast enhancement being observed dynamically with FLASH2D or TurboFLASH imaging. The patient is prepared in a similar manner as described above, including ECG leads and peripheral i.v. cannula, yet excepting the restriction on intake of xanthines since no pharmacological stress will be induced. Positioning in the magnet is head first and supine in the body coil. Sagittal scout views are obtained to allow positioning of a series of coronal oblique breathhold FLASH2D images of the kidneys. In this survey series, the slices are obliqued 10° from coronal to transverse to reduce in-plane flow saturation (signal loss), and an inferior presaturation band below the kidneys provides an arterial MR angiogram. The slice position is incremented between each single slice breathhold scan until the kidneys are covered from back to front. Imaging parameters for the FLASH2D sequence are: TR=23-25 ms, TE=10-12 ms, flip angle=30°, FOV=450 mm, slice thickness=5 mm, and acquisition matrix=192x256 (figure 4). From these survey slices, one is selected which best demonstrates the maximum amount of both kidneys, including a portion of the aorta and the left atrium. This slice position and orientation is used to acquire the dynamic single slice TurboFLASH perfusion images. We suggest using the same parameters as described above for cardiac perfusion imaging except with an increased FOV=450 mm, slice thickness=10 mm, matrix=124x256, without ECG gating, and during about 3 minutes of quiet breathing. The same slice is imaged repeatedly (using a distance factor of -1) every 5 seconds for a total of 36 images. A bolus of 0.04 mmol/kg Gadolinium is given, followed by a 20 ml saline flush, and imaging is commenced after a 10 second delay (timed from start of contrast injection). Or, if FLASH2D is used rather than TurboFLASH, the same slice is imaged repeatedly every 10 seconds for a total of 18 images (figure 5). These parameters can be varied to alter temporal resolution and the total imaging time is easily varied. The technique for other upper abdominal solid organs (figures 6 & 7) is similar to that for renal perfusion imaging except that the plane of acquisition will be dictated by the anatomy/pathology suspected and information sought. Oblique coronal imaging is usually a helpful starting point except for the pancreas (where axial images are more suitable).

Clinical Interpretation of Renal Perfusion

The FLASH2D survey images are inspected for anatomy and pathology and can be MIP'd as an MR angiogram. Then the TurboFLASH or FLASH2D perfusion images are viewed as a cine loop for qualitative estimation of differential renal perfusion. More accurate analysis of perfusion requires the generation of comparative TSCs using ROIs for the abdominal aorta and each kidney (or part thereof) similar to isotope renography time/count density curves. If the left atrium is included, an aortic transit time can be estimated. This may be used to put any delay in renal perfusion (with respect to the aorta) into perspective, vis-a-vis the patients overall cardiac function and output.

Future Considerations

Once perfusion techniques of this type have been clinically evaluated on a large scale, they may replace conventional nuclear medicine studies in some areas or they may carve out their own niches. MR perfusion imaging with echo planar techniques (EPI) may be even faster, especially with the realization of reliable breathhold volume acquisitions to increase the amount of tissue examined. Furthermore, recent work holds out the promise that tissue perfusion may be measured with magnetization transfer and/or RF tagging techniques, obviating the need for contrast agent administration.

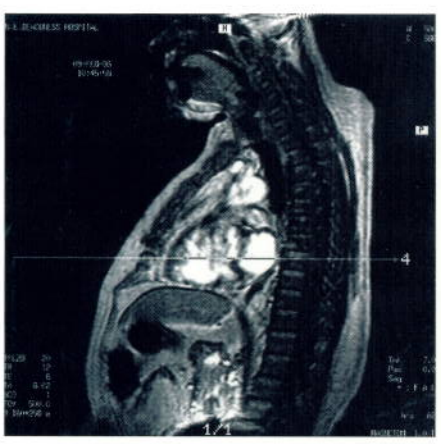


Figure 8. Initial sagittal breathhold TurboFLASH scout shows the position of the first axial scout to image through the center of the left ventricle.

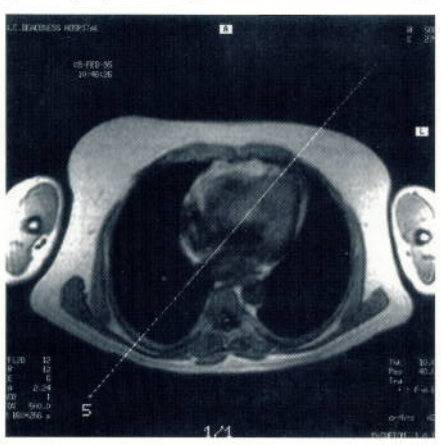


Figure 9. Axial breathhold TurboFLASH scout shows the position of the oblique coronal (RAO equivalent) scout used for positioning the short axis perfusion images.

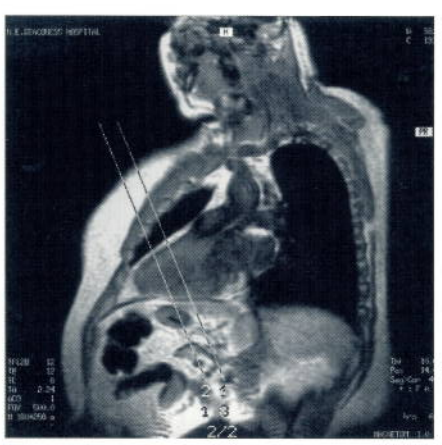


Figure 10. Oblique coronal TurboFLASH scout shows the position of the short axis perfusion images.

Suggested Further Reading

Manning WJ, Atkinson DJ, Grossman W, Paulin S, Edelman RR. First-pass nuclear magnetic resonance imaging studies using gadolinium-DTPA in patients with coronary artery disease. J Am Coll Cardiol 1991;18:959-965

Pennell DJ, Underwood SR, Ell PJ, Swanton RH, Walker JM, Longmore DB. Dipyridamole magnetic resonance imaging: a comparison with thallium-201 emission tomography. Br Heart J 1990;64:362-369

Klein MA, Collier BD, Hellman RS, Bamrah VS. Detection of chronic coronary artery disease: value of pharmacologically stressed, dynamically enhanced turbo-fast low-angle shot MR images. AJR 1993;161:257-263

Applications Tips

(continued from page 2)

High Resolution Spines

❑ Vision	☑ Impact
❑ SP	❑ Open

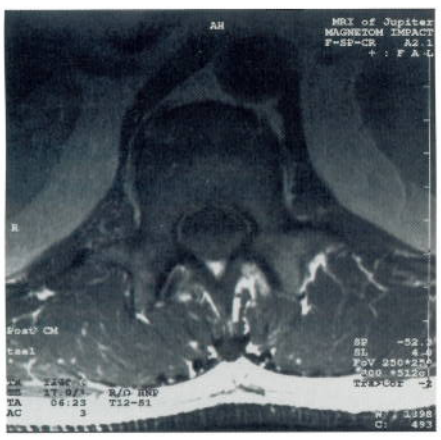
These MAGNETOM Impact protocols were optimized by MRI of Jupiter, FL. They provide high resolution, transverse, T1- and T2-weighted images of the lumbar spine for Impact users with the CP-spine coil who have the basic TURBO software option without the POWER PACKAGE software option.

T1-weighted:

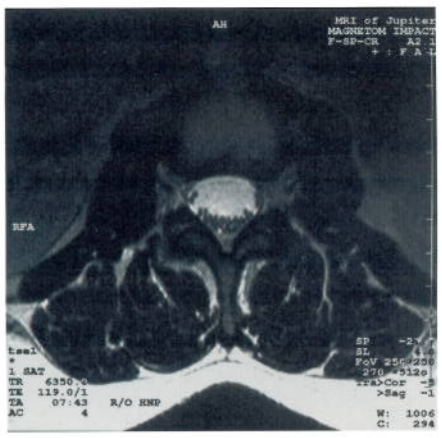
tse3_17b130.ufa
tr=1260
te=17
fov=250
matx=300x512,o
acq=3
thick=4
gap=0.25
presats=no
swap=yes
filter=no
time=6:23

T2-weighted:

tse15_119b130.ufa,
tr=6350
te=119
fov=250
matx=270x512,o
acq=4
thick=4
gap=0.25
presats=no
swap=yes
filter=no
time=7:43



T1 axial lumbar



T2 axial lumbar

Image Text Codes

☑ Vision	☑ Impact
❑ SP	☑ Open

The following image text codes may be found in the lower left corner of images acquired on the MAGNETOM Open Impact, or Vision systems. Refer to section A.2 of the Numaris Reference Guide: The Numaris Workshop.

*	Siemens sequence
D	Door open during meas.
R	Raw data filter
I	Image filter
S	Sinc interpolation
U	Incomplete raw data set
+C	Contrast agent
H	Head first
F	Feet first
SP	Supine
PR	Prone
LL	Left lateral
RL	Right lateral
CR	Cranial
CA	Caudal
SP	Slice position
SL	Slice thickness
MF	Magnification factor
Cor	Coronal slice orientation
Sag	Sagittal slice orientation
Tra	Transverse slice orientation

Intensity Scaling

☑ Vision	☑ Impact
☑ SP	☑ Open

If your MAGNETOM images are requiring extremely low (<500) or extremely high (>3500) window settings for appropriate filming, perhaps the intensity scaling factor is not optimized for one or more coils. The intensity scaling factor is initially calibrated for each coil during your system installation, but may need to be recalibrated periodically following any system tune-ups, coil adjustments/repairs, or software reloads. Recalibration should be done only by a Siemens-trained service engineer or applications representative. On the MAGNETOM SP system the intensity scaling factor is called SCALE CORRECTION FACTOR while on the MAGNETOM Open, Impact, and Vision systems it is called FFT FACTOR. To check the calibration of the intensity scaling factor for a particular coil, display a routine T1-weighted spin echo image and reduce the WINDOW to its minimum value (2). Then, gradually increase the CENTER from its minimum value until the last pixels (fat) finally disappear. If this does not occur between the values of 1500 and 3000, the intensity scaling factor may need to be recalibrated for that coil.

Protocol Printout

❑ Vision	❑ Impact
☑ SP	❑ Open

If your MAGNETOM SP system comes with a printer, it is relatively simple to get a protocol printout on these systems, as described below. On the MAGNETOM SP system the SEQUENCE/PRINT command can take a while to print. It is recommended to perform this task while the system is idle. Once this command has been initiated it is not possible to perform other tasks. A message "Sequence Print Completed" will indicate when the command is finished. Although the SEQUENCE/PRINT command creates a text file named [SEQUENCE]SEQ_PRINT.PPT on the VAX computer, it may or may not automatically print that file, depending upon how the printer is configured. Therefore, prior to beginning, your service engineer should physically connect the printer to port OPA0 and then run the PARTIAL INSTALL program to configure the printer to that port. If this fails to produce an automatic printout of the text file following the message "Sequence Print Completed", the service engineer may manually print the text file by logging into the VAX computer from his service terminal. To perform the sequence print function on the SP, type at the main console (* indicates wildcard character):

SEQ/PRINT for all families.

SEQ/PRINT=BODY.*
for only BODY family.

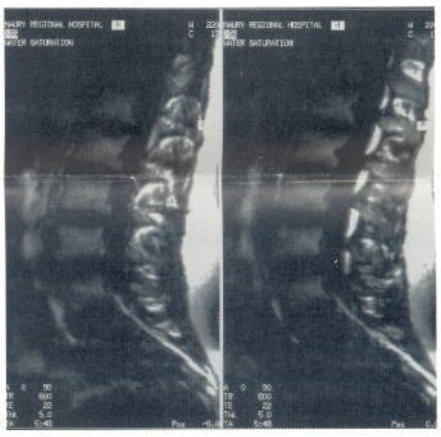
SEQ/PRINT=BODY.LIVER.*
for only BODY family, LIVER group.

SEQ/PRINT=BODY.LIVER.T1AX
for only BODY family, LIVER group, T1AX protocol.

Water Saturation

☑ Vision	☑ Impact
☑ SP	❑ Open

On the MAGNETOM Impact or Vision systems the easiest way to accomplish water saturation is with an Inversion Recovery technique called FLAIR (see in this issue APPLICATIONS TIPS: FLAIR TECHNIQUE). This provides T2-weighted images with fluid signal attenuated when using TR=5000-6000, TE=110-150, and TI=1800-2000. However, if spectral water saturation is desired, the Impact, Vision, and SP systems can accomplish this by running a Fat Sat sequence with the saturation pulse centered over the water peak rather than the fat peak. To accomplish this on the Impact or Vision systems the center frequency of the system is shifted up by the appropriate amount prior to scanning with a Fat Sat sequence. To accomplish this on the SP system the saturation pulse is centered over the water peak rather than the fat peak by selecting a zero (0 Hz) offset from the @FSFIX menu. Remember that the fat and water peaks are separated by approximately 145 Hz at 1.0 Tesla or by approximately 220 Hz at 1.5 Tesla; the frequency separation is minimal at 0.2 Tesla on the MAGNETOM Open system. For the **Impact** or **Vision** systems: select a T1-weighted Fat Sat protocol, set the inline adjustments=none, do a manual frequency adjustment, add the desired shift to the system frequency, do a manual receiver adjustment, then do the scan. For the **SP** system: select a T1-weighted Fat Sat protocol, set the saturation pulse to zero shift (0 Hz) with @FSFIX, then do the scan. Although you may tinker with the frequency shift to optimize the results, you will not see any changes in the image with small frequency changes of 25 Hz or less. Be aware that spectral water saturation techniques are very sensitive to any shim or susceptibility artifacts (i.e., breasts are notorious for creating susceptibility artifacts); thus, you may need to follow shim optimization procedures for this technique just like you would for Fat Sat techniques.



Water saturation image, sagittal lumbar spine.

(**Applications Tips** *continued on page 6)*

MRI Resources: Textbooks & Workbooks

This list of commonly available textbooks and workbooks is provided to the reader as a study aid for preparing for the upcoming MR technologist registry examination.

- Magnetic Resonance Imaging, D. Stark & W. Bradley, 1992, 2 volume set, call C.V. Mosby Company at (800)426-4545 for additional copies at about $350 per 2 vol set.
- Clinical MRI, R. Edelman & J. Hesselink, 1990, call W.B. Saunders Company at (800)545-2522 for additional copies at about $240 each.
- Magnetic Resonance Imaging of the Spine, M. Modic, T. Masaryk, & J. Ross, 1994, call C.V. Mosby Company at (800)426-4545 for additional copies at about $140 each.
- MRI of the Abdomen, R. Semelka & J. Shoenut, 1993, call Raven Press at (212)930-9541 for additional copies at about $100 each.
- Clinical MR Angiography, C. Anderson, R. Edelman, & P. Turski, 1993, call Raven Press at (212)930-9541 for additional copies at about $142 each.
- MRI in Orthopaedics and Sports Medicine, D. Stoller, 1993, call J.B. Lippincott Company at (800)777-2295 for additional copies at about $245 each.
- Magnetic Resonance Workbook, N. Matwiyoff, call Raven Press at (212)930-9541, order code 2029, for additional copies at about $40 each.
- MRI Workbook for Technologists, C. Kaut, call Raven Press at (212)930-9541, order code 2376, for additional copies at about $45 each.
- Magnetic Resonance Imaging: Physical and Biological Principles, S. Bushong, Dec 1994, call C.V. Mosby Company at (800)426-4545 for additional copies at about $45 each.

Applications Tips *(continued from page 5)*

T1/T2 Intensities

☑ Vision ☑ Impact
☑ SP ❑ Open

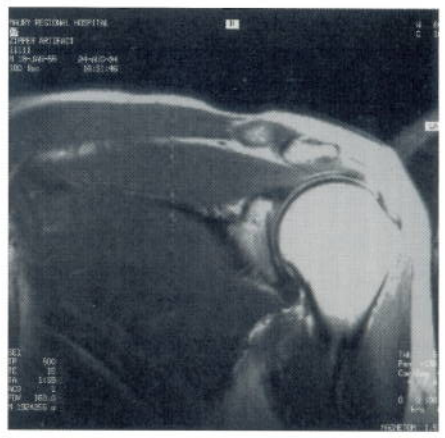
The following table of T1 and T2 signal intensities are reprinted by permission from R. Edelman et. al., New England Journal of Medicine, March 11, 1993:

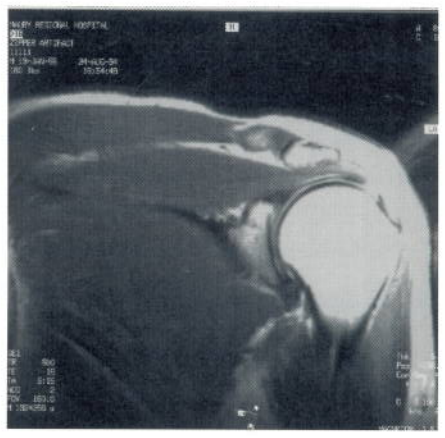
TISSUE	T1-WT IMAGE	T2-WT IMAGE
fat	very bright	intermed - dark
cyst		
simple	very dark	very bright
proteinaceous	intermed - bright	very bright
brain		
white matter	bright	moderate dark
grey matter	moderate dark	moderate bright
csf	very dark	very bright
ms plaque	intermed - dark	bright
bland infarct	dark	bright
tumor	dark	bright
meningioma	intermed	intermed
abscess	dark	bright
edema	dark	bright
calcification	variable	variable
bone marrow		
yellow	very bright	intermed - dark
red	intermed	moderate dark
bone mets		
lytic	dark	intermed - bright
sclerotic	dark	dark
cortical bone	very dark	very dark
cartilage		
fibrous	very dark	very dark
hyaline	intermed	intermed
spine disk		
normal	intermed	bright
degenerate	intermed - dark	dark
tendon & ligament	very dark	very dark
normal	very dark	very dark
inflamed	intermed	intermed
torn	intermed	bright
muscle	dark	dark
lung	very dark	very dark
liver		
normal	moderate bright	dark
mets	dark	moderate bright
hemangioma	dark	very bright
pancreas	moderate bright	dark
spleen	dark	moderate bright
Gd-DTPA enhanced		
low concentrate	very bright	bright
high concentrate	intermed - dark	very dark
hematoma (@ 1.5T)		
acute	intermed - dark	dark
subacute	bright rim	bright
chronic	dark rim (+-bright center)	dark rim (+-bright center)

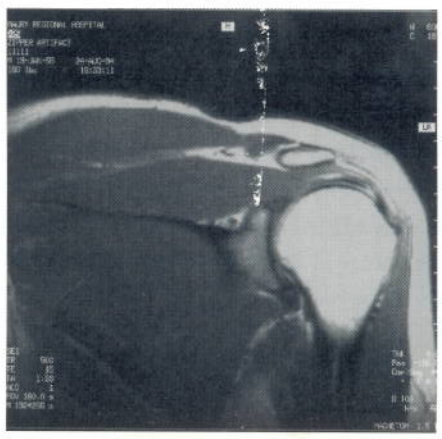
Zipper Artifact

☑ Vision ☑ Impact
☑ SP ☑ Open

A linear "zipper" artifact may appear in your off-center FOV shoulder or knee images measured with one acquisition. There are two methods to eliminate this artifact. One method is to use an even number (2, 4, 6, etc.) of acquisitions. This is quite practical for most imaging protocols. Even for T2 spin echo protocols which traditionally use only a single acquisition, Half Fourier and dual acquisitions can be combined to keep the imaging time to a minimum. An alternate method to eliminate this artifact is to shift the off-center FOV in the frequency encoding direction rather than the phase encoding direction, but remembering to watch for wrap-around or flow artifacts. For example, a coronal oblique shoulder acquired with one acquisition and with phase/frequency not swapped may produce a "zipper" artifact (top right). However, the artifact is eliminated simply by using two acquisitions (middle right) or by swapping phase/frequency directions (bottom right).







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