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MAGNETOM Flash

An Applications Reference for Siemens MAGNETOM Users

From the Editor

Many of you have waited for new issues of the MAGNETOM® Flash. This issue is the first issue since over one year.

How did this happen?

For 4 years Gary McNeal served the MAGNETOM Flash as editor giving time and ideas to each issue. He moved on to provide application support for the US now. Here is the place to thank him for his great work.

The editorial was then vacant for a few months, when I finally took it over. It took some time to get into the process of creating, organizing, printing and logistics of a magazine such as the MAGNETOM Flash. We will work hard to come again to a regular publication with three to four issues per year.

What has changed?

Except the format, layout and the editor of the magazine nothing has changed dramatically. We will maintain the MAGNETOM Flash as a primarily application oriented reference for you. It continues to be a forum to share clinical and technical ideas among the MR users. We intend to keep you updated with news for software and hardware updates of the various MAGNETOM systems, application hints, and articles about new techniques as well as how to optimize "old" techniques. You will find information about upcoming meetings and seminars we know of.

A new topic is introduced with the column "Product News". Here you will find short notes on hardware product updates. We will also provide information on new educational material you can get through the Applications Helpline (phone number 800-767-2313 in the US) or worldwide through your local product and applications specialists.

At this point I want to thank you for your patience. Additionally, I have to apologize to the authors of the articles for this issue for being so late.

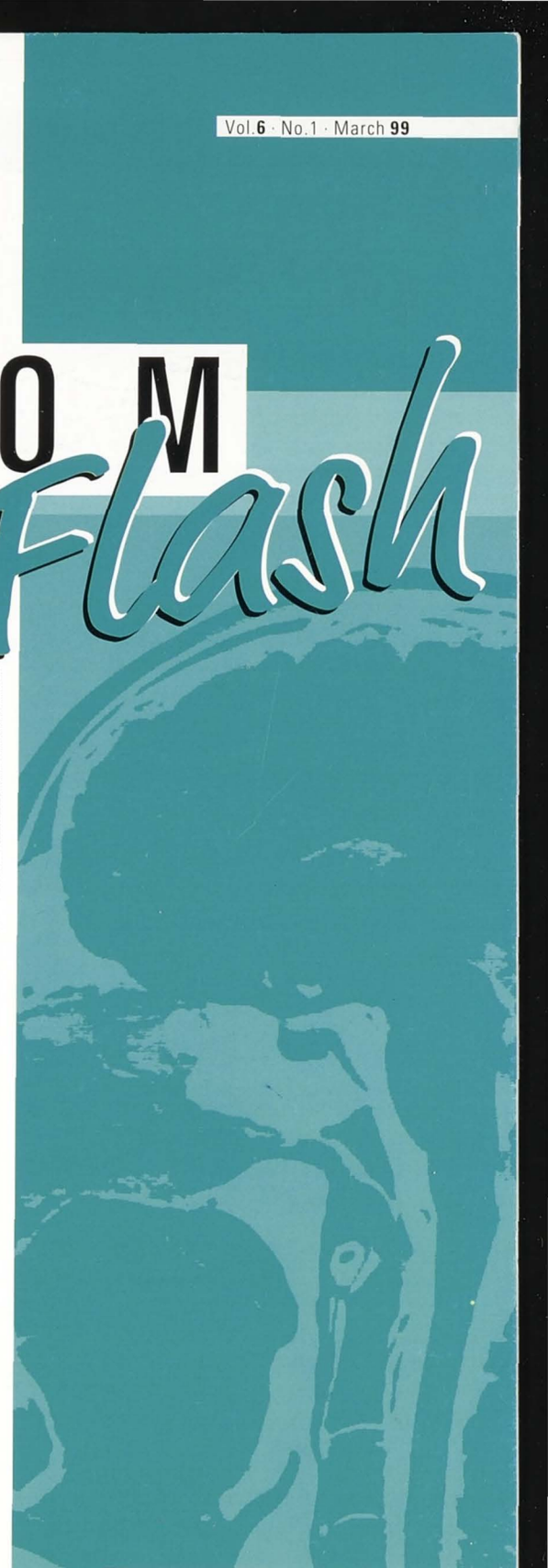
Change of address? You want to be added to the mailing list?

If you are within the US please contact the Applications Helpline and send your name and business address (no home addresses, please). Outside the US, the MAGNETOM Flash is distributed through the local Siemens offices. However, please contact me, I will take care that you are getting onto the distribution list of your local support.

Finally, as MAGNETOM Flash is an educational magazine for MAGNETOM users, it lives through your experience and contributions. If you want to submit an article and share your experience please contact me.

Hopefully you will find the information provided in this MAGNETOM Flash issue helpful. The next issue is already in preparation and will update you on the coming software B33A, C-Spine imaging and some product news.

Dagmar Thomsik-Schroepfer, Editor



:In this issue:

:GOP Enhance Filter:

Sheila Bero, B.S.R.T. (R), (MR), (CT), Siemens MR Applications Specialist

The GOP Enhance Filter available on MAGNETOM systems, is a software program for context controlled restoration of digital images. The filter implements the GOP® Image Restoration Operation, to recover a high quality image from a degraded image.

The filter can increase the signal-to-noise ratio as well as improve the visual appearance of the image without blurring structural information. The most common degradations are errors caused by statistical noise or motion or a combination of both.

The filter utilizes 4 separate components:

- a stationary isotropic low-pass filter, which reduces the noise.
- a non-stationary anisotropic component that provides directionally sensitive structure (edge and line) enhancement.
- a non-stationary high-pass component controlled by local structure curvature and consistency and image variance.
- a hypercomplex local area which enables a weighted all-pass filter.

Different types of images need different degrees of noise reduction. Therefore a selection of smooth, medium or sharp smoothing factors can be selected (ranging from 1 to 10). If set to sharp (e. g. 10), a high degree of structure (edge/line) enhancement is achieved. In the medium range (e. g. 5), a combination of both noise reduction and structure enhancement is done. If set to smooth (e. g. 1), mostly noise reduction is done with very little edge enhancement (image no 1a-d).

The latest version of MAGNETOM software includes an additional range of smoothing factors (from 11 to 20) which has been tuned especially for 512 x 512 images, but this range can also be used on other image sizes. Smooth, medium, or sharp correspond to low, medium, and high values within this range 11-20. A lower number here (e. g. 11) gives more noise reduction but also higher signal amplication compared to a higher value (e. g. 20). The high value (20) shows very little change to the original non-filtered image. Using the upper levels (11 to 20) therefore provides image enhancement without the usual "filtered" look (image no 2a-f, 3a-f).

To access the GOP Enhance Filter, go to the main menu and select *"Evaluate/ Filter"*. In the filter window click *"Select Images"* from the popup window and select the appropriate patient and study. When the selection is made for one or several sets of images click *"Select"*, you will start the filtering by a click on the *"Run List"* button. The images will be processed and automatically sent back to the database as new studies. During the filtering process, the user may iconify the base window and work on other things. (NOTE) It is very important not to exit the base window, as this will stop all the jobs you have requested and exit the application.

If you would like to select specific images from a particular study simply select the patient and the study from the image list, click on the images you do not want to be filter, and they will be de-selected. If you want to select only a few images from many, press the right mouse key with the cursor in the *"Images"* list. From the submenu select the *"Clear All"* choice. Then click on the few images you do want to filter, then click *"Select"*, then *"Run list"*.

When you iconify the base window rather than exiting the base window, the patient list is not updated as new patients are scanned. So, to update the patient list, move the cursor to the patient list, press the right mouse key and a submenu will appear. In this menu you may select *"update list"*. In this submenu you also have the ability to sort the patient list either by name or study number. Alternatively, you can cancel out of the patient list window and click on *"Select Images"* again. This will also update the patient list.

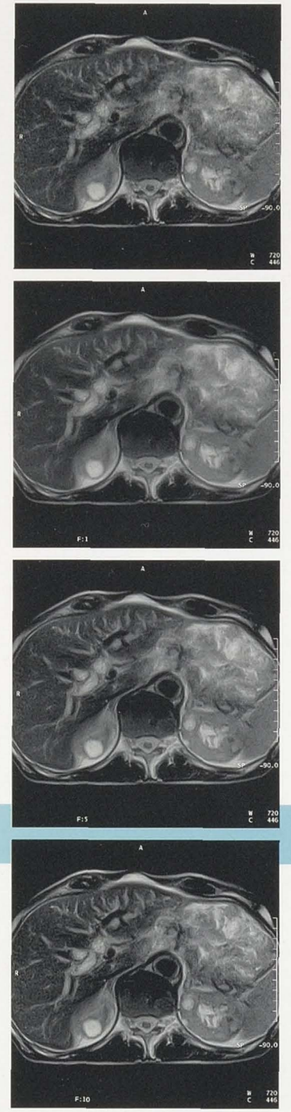
Each new study resulting from running the GOP Enhance Filter will be named such as "F13:14:StudyName" where "F13" stands for the filter smoothing factor that was applied, "14" stands for the source study number and "StudyName" is taken from the original unfiltered source study. So when selecting a new study for filtering you can easily see which studies have already been filtered and should not be filtered again.

The default filter values in VB3.1B software for smooth, medium, and sharp are "15, 17, and 19", but you may set new filter values and store them under a unique name. To set new filter settings, select *"Filter defaults"* from the *"Select Images"* Window and a popup window titled *"Filter Defaults"* will open. Enter the new values your desire. Enter in a new default name by putting the cursor on the text line, using backspace to erase the existing name and typing in a new name, saving the new name, and accepting this new setup. This loads the new settings into the *"Select Images"* popup menu. Alternatively, if you select *"Cancel"*, this closes the Filter Defaults menu without loading the new values.

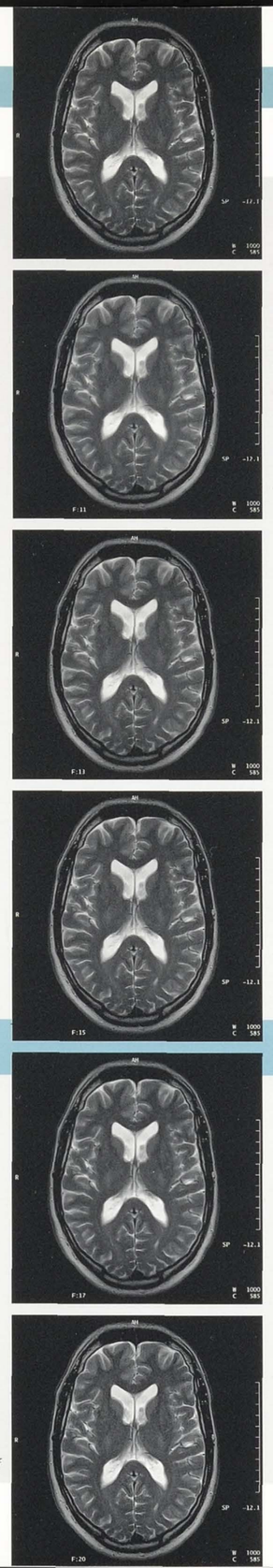
No 1a-d
The first image shows the original visual appearance of a Turbo Spin Echo liver study with 195 x 260 FoV and 145 x 256 matrix. Sharp (1b), medium (1c) and smooth (1d) filter factor were selected to visualize the impact of various filter values. Original data with courtesy of Klinikum Mannheim, Germany.

No 2a-f
Turbo Spin Echo head image with 230 x 230 FoV and 255 x 512 matrix was filtered with various filter values (F:11; F:13; F:15; F:17; F:20).

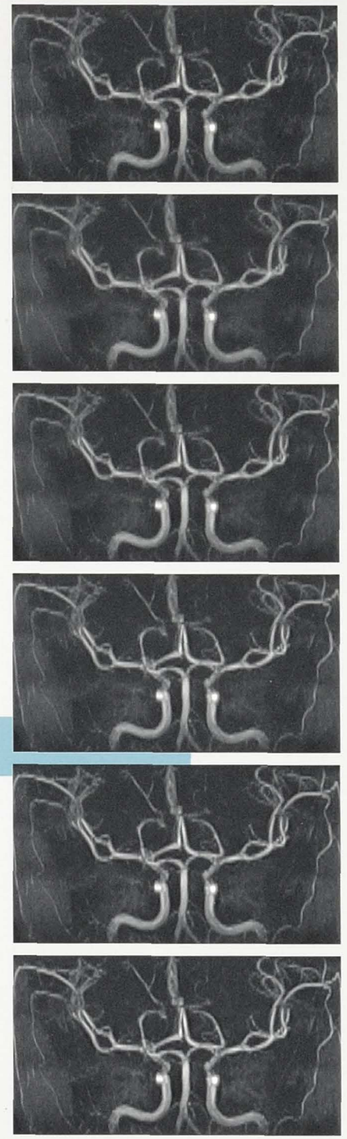
No 3a-f
The GOP Enhance filter gives MR Angiography studies sometimes a more appealing visual appearance. This ICV study has a 150 x 200 FoV, 192 x 512 matrix and underwent filtering with F:11, F:13, F:15, F:17 and F:20. Original image with courtesy of Diagnostic Specialties, Indiana, US.



No 1a-d



No 2a-f



No 3a-f

PART 1

Non-Echo-Planar Fast MR Imaging Techniques

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INTRODUCTION

Speed is of key importance in MR imaging. In the early days, MR was considered a slow imaging technique as the scan time was typically over 10-20 minutes. During the image acquisition time, any source of motion would cause image degradation. Thus, MR images were readily affected by physiologic motions and/or voluntary motions. Respiratory motions and the beating motion of the heart were particularly problematic for thoracic imaging. Abdominal imaging were often marred by respiratory motion artifacts.

In order to overcome these problems, a multitude of fast imaging techniques have been developed and tested clinically. Echo planar imaging (EPI) is currently the fastest way to generate an image. With EPI a complete image can be measured in less than 100 ms thus avoiding most of the physiologic motion artifacts. However, it requires substantial hardware modifications and is not yet in widespread use. Furthermore, it faces certain limitations, such as substantial chemical shift artifacts, limited spatial resolution, and the possibility of tissue stimulation. With this in mind, there are other fast imaging techniques that offer a broad spectrum of clinical applications. The purpose of this review is to outline the basic principles of these non-EPI fast imaging techniques. Since the field of MRI is rapidly progressing and new pulse sequences are being created all the time, we will focus on pulse sequences that are already under clinical investigations.

COVERAGE OF K-SPACE

The raw data for MR imaging is best represented by the k-space (Fig. 1). The k-space refers to the spatial frequency which is an abstract formulation of an image. k_x and k_y are given by:

$$k_x = \gamma G_x t \qquad (1)$$

$$k_y = \gamma G_y \tau \qquad (2)$$

where γ is the gyromagnetic ratio, G_x and G_y are the gradients along x and y respectively, and τ refers to the length of the phase encode gradient pulse. The units for k_x and k_y are in radians/cm. As shown in the equations, k_x and k_y are linearly proportional to the gradient strength and the time duration. The k-space domain is very helpful in interpreting MR imaging: the center points of k-space provide the overall contrast and signal of an image. The outlying k-space data points, on the other hand, contribute to the definition of edges (high spatial frequencies). A higher value for k_x and k_y denotes higher spatial frequencies and therefore higher spatial resolution, which is achieved by applying a large gradient amplitude or a longer gradient duration. The raw data in the k-space domain is transformed into the image domain by a Fourier transformation. The k-space formalism can readily be used to analyze and compare the nature of different pulse sequences with regard to image contrast and scan time.

SCAN TIME

The measurement time needed to generate a study is the time needed to collect all the necessary raw data in k-space. In conventional MR imaging, the time taken to acquire data along k_x is relatively short (in the order of msecs). Data collection along k_y is more time consuming and in conventional spin echo imaging, it takes several seconds from one k_y line to the next (for T2- weighted imaging). The scan time T_s is given by equation 3:

$$T_s = TR \bullet N_y \bullet NEX \qquad (3)$$

The scan time increases with the repetition time (TR), the number of phase encode steps (N_y), and the number of averages (NEX). As a longer TR of typically 2-3 seconds is needed for T2-weighted imaging, the scan time for a conventional spin echo T2-weighted study is in the order of 8-13 minutes for a 256 x 256 imaging matrix. With the development of new imaging techniques in combination with faster gradient systems, it is now possible to perform MR imaging substantially faster than before.

REDUCTION OF SCAN TIME

In conventional imaging strategies (both spin echo and gradient echo), each k_y line of k-space is covered in a separate TR. Therefore the scan time is given by equation (3), and faster scanning can be accomplished by reducing TR, N_y, or NEX. At the other end of the spectrum, all of k-space is covered after one single RF excitation (Fig. 2). This category of imaging techniques is referred to as single-shot imaging. A typical representative of this category is echo planar imaging (EPI). Between these two lie a range of rapid imaging techniques, in which k-space is covered in segments. Each segment contains a number of data lines (in k-space) which are acquired after each RF excitation. Consequently, the scan time is reduced, as fewer TR intervals are necessary to acquire all lines of k-space. A typical example for this category is Turbo Spin Echo, and this category is referred to as hybrid imaging, which differs itself from conventional techniques and single-shot techniques. It will be beyond the scope of this paper to include each and every one of the new techniques. Therefore, we will focus on the major ones that have demonstrated clinical applications.

The scan time can be reduced in a number of ways. These time-saving strategies can be applied to a variety of MR imaging techniques.

Reduce the number of averages (NEX).

The development of advanced RF coils (such as phased array coils) leads to major improvements in the signal-to-noise ratio (SNR). This is particularly important in body imaging. The application of a body array coil typically improves the SNR by a factor of two. As a result, multiple averages needed in earlier days are no longer necessary. With major reduction in scan time, it is now possible to acquire abdominal images within a single breath-hold to eliminate any respiratory motion artifacts. One could even have NEX less than 1. For example, half-Fourier imaging reduces NEX to ½ and further diminishes the scan time. Half Fourier is possible due to the fact that k-space is Hermitian in nature. Based on the expected symmetry, one could generate the rest of the data acquiring only half of the data in k-space. In actual practice, slightly more than one half of the data is acquired. Consequently, the scan time is cut in half at the cost of a reduction in signal-to-noise by about SQRT(2).

Reduce the repetition time (TR).

In spin echo sequences, the TR is typically in the order of several hundred milliseconds (depending on the desired contrast). Much shorter TRs are possible with gradient echo sequences.

Currently, the minimum TR of gradient echo sequences can be as short as a few milliseconds. This is made possible by the improvement in the system hardware, in particular, the magnetic field gradient system. Due to the short TR of gradient echo sequences a variety of new clinical applications has become available, in particular 3D imaging. Note that while reducing the TR shortens the scan time (according to equation 3), it also alters the overall image contrast, as the amount of T1-weighting is changed. Special care of imaging parameters is necessary to maintain an acceptable balance between scan time and image contrast.

Acquire fewer ky lines.

In combination with a flexible rectangular field-of-view (FOV) technique fewer lines can be used to shorten the scan time. This is applicable when the region of interest is ellipsoid in the imaging slice. The image contrast and spatial resolution are maintained at the cost of a reduced signal-to-noise ratio.

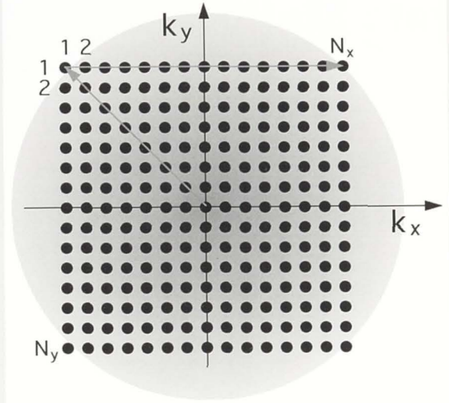

Figure 1:
k-space scanning. A set of $N_x \bullet N_y$ data points are measured to scan the raw data of the object. Points in the center of k-space define image contrast, outlying data points define the spatial resolution in the image.

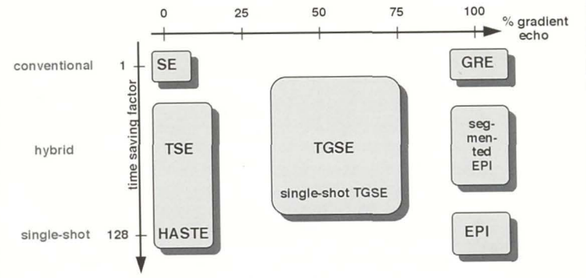

Figure 2:
k-space scanning strategies. In the conventional category one line of k-space is acquired per TR interval.
Each line is acquired by sampling an echo which is created by a 180° refocussing pulse (spin echo, SE), or by gradient reversal (gradient refocused echo, GRE). Single-shot techniques scan all of k-space after one RF excitation, and provide the largest time saving factor. In between these extremes there is a variety of hybrid imaging techniques.

Part 2 to be continued in Vol.6 No.2.1999

Chemical-Shift Gradient-Echo MR Imaging: an Accurate Method to characterize Liver Nodules for Fat Content

Julio Martin, MD. Xavier Catasus, MD. Jordi Puig, MD

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Two main groups of pulse sequences are in use in magnetic resonance imaging; spin echo (SE) and gradient recalled echo (GRE). Because of the 180 degree refocusing pulse, signals from water and lipids are in-phase, relative to each other, in conventional SE sequences, and they contribute additionally to the net signal intensity on the final image. Therefore the final signal intensity of a given voxel with a mixture of water and lipids on SE images is the summation of the signals from water and fat because the echo is obtained when the vectors of water and lipids are in phase.

Opposed-phase images, where water and lipid signals interfere destructively, can be obtained by changing the 180 degree refocusing pulse so that the phases of triglycerides and water magnetization are opposite each other when the echo is formed (1).

On GRE sequences the magnetization vectors from water and fat are in- and opposed-phase alternatively with appropriate echo times (TE) that are field strength dependent. At 1.0 Tesla, echo times of approximately 4, 11 and 18 ms yield opposed-phase images and echo times of approximately 7, 14 and 21 ms yield in-phase images. In our institution the MR protocol for focal liver lesions always include chemical-shift FLASH imaging: In-phase images (at 1 Tesla) are obtained at 110 or 135/7/90 degree (TR/TE/FA). We use a TR of 110 or 135 ms depending on the number of slices to cover the liver. The duration of these sequences is 16 or 19 s depending on the TR used, yielding 11 or 13 slices, respectively, for the opposed-phase sequence and 7 or 9 slices for the in-phase sequence. The opposed-phase sequences uses a TE of 10 ms. Tissues containing mainly water show similar signal intensities on both in- and opposed-phase (Fig. 1), whereas tissues with a mixture of fat and water exhibit low signal intensities on opposed-phase images because the signal from water cancels the signal from fat, whereas their signals are added together in the in-phase condition (Figs 2, 3). A variation of the signal intensity between in-phase and opposed-phase images conclusively indicates a fatty-tissue component in the tissue. Lipomatous nodules of the liver are very infrequent, they include lipoma, angiomyolipoma, myelolipoma and round focal fatty infiltration. In cirrhotic patients the detection of fat content in a nodule is strongly suspicious of hepatocellular carcinoma with fatty metamorphosis (Fig 3) (2,3).

The lipomatous component of hepatic nodules may be very difficult to demonstrate by means of ultrasonography (US), computed tomography (CT) or conventional MRI because it causes non-specific hyperechogenicity on US and if the amount of fat is not enough, the CT attenuation values are close to water density. Concerning MR imaging, fat generally produces high signal intensity, especially on T1-weighted images, but high signal intensity can also be seen on old hematomas, lesions with melanin and lesions with excessive copper accumulation.

Unlike other imaging modalities, chemical-shift MR imaging is a proven technique for confirming the presence of fat in tissues. It provides a definitive method for differentiating lesion that contain water from those that contain both water and fat (4-7). Lesions with a mixture of fat and water exhibit low signal intensity on opposed-phase images because the signal from water

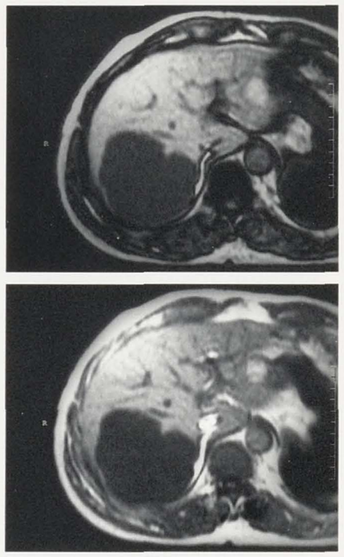

Figure 1.
Hepatic cavernous hemangioma. (a) Opposed-phase T1-weighted FLASH image shows a hypointense hepatic mass corresponding to a hemangioma. The mass shows the same signal intensity on in-phase image (b) which indicates the mass is composed entirely of water.

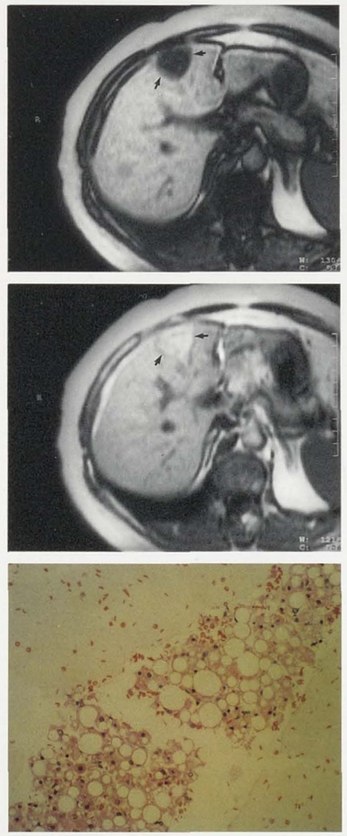

Figure 2.
Nodular focal fatty infiltration (arrows in a and b). (a) The lesion is notably hypointense on the opposed-phase image due to the signal cancellation between water and fat, and hyperintense on the in-phase image (b) due to addition of the signal intensities of water and fat, thus confirming the fat content of the lesion (c). Section of cell block shows hepatic tissue with marked steatosis. Hematoxilin and eosin x 200.

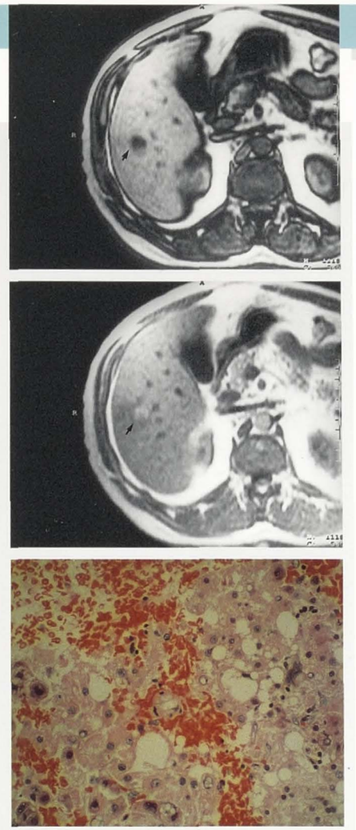

Figure 3.
Hepatocellular carcinoma with fatty metamorphosis (arrows in a and b) (a). On opposed-phase FLASH image the nodule is notably hypointense compared with the in-phase image (b). This signal intensity variation indicates the lipomatous nature of a nodule. (c) Section of cell block obtained by fine-needle aspiration shows hepatocellular carcinoma with extensive fatty change. Some hepatocytes show marked nuclear hyperchromasia and pleomorphism (hematoxylin and eosin stain: original magnification, x 200).

cancels the signal from fat, whereas they exhibit high signal intensity on in-phase images because the signals are summed. The variation of signal intensity between in-phase and opposed-phase images conclusively indicates fatty-tissue in the lesion.

In conclusion, chemical-shift GRE imaging technique allows us to accurately characterize hepatic lesions for fat content.

Note: If utilizing the in- and opposed-phase imaging technique on other MAGNETOM systems (e. g. Vision or Open) the following table may assist you in determining the correct echo time. Please note that longer echo times (TE) also introduce more T2* decay and therefore additional changes in contrast.

TE's for Fat/Water Phases at 1.5 T

0.0	2.3	4.5	6.8	9.0	11.3	13.5...
in	out	in	out	in	out	in...

TE's for Fat/Water Phases at 1.0 T

0.0	4.0	7.0	11.0	14.0	18.0	21.0...
in	out	in	out	in	out	in...

TE's for Fat/Water Phases at 0.2 T

0.0	16.8	33.6	50.4	67.2	84.0	100.8...
in	out	in	out	in	out	in...

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New Coils for MAGNETOM Impact/Expert/plus and Vision/plus MAGNETOM Symphony and Harmony

Shoulder Array Coil

The new Shoulder Array Coil has a stable exterior to allow easy patient positioning, which translates into time savings for patient set up. Depending on the size of the shoulder either the small or the large coil is used. This is placed either left or right in one of the slots on the base plate depending on the patients' size.

The Shoulder Array Coil provides excellent images to evaluate partial and complete tears of the rotator cuff as well as visualization of labral and capsular pathology. The new design of the coil offers high signal to noise ratio and the combination with the array principle ensures high field homogeneity. Thus signal overflow from subcutaneous fat is reduced, leading to improved image quality. The higher signal-to-noise ratio can be used either to increase spatial resolution or to shorten exam time.

The Shoulder Array Coil consists of a set of base plate, two Array Coils and soft pads for high patient comfort:

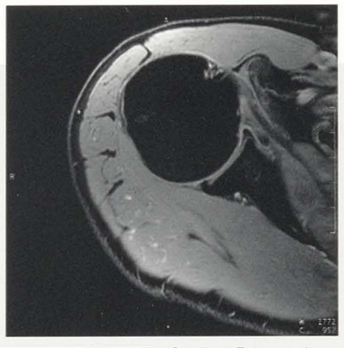
- Weight of base plate: approx. 5 kg

Small Shoulder Array Coil:

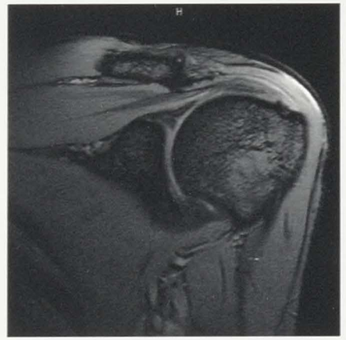
- Opening 165 mm
- Weight: 1.3 kg

Large Shoulder Array Coil:

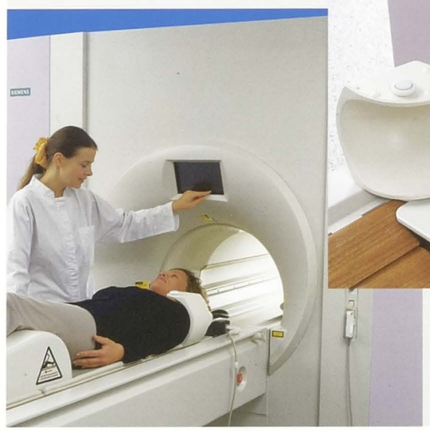
- Opening 200 mm
- Weight: 1.6 kg



Gradient Echo study with fat suppression acquired in 4:31 min. 512 matrix, 0.4 mm spatial resolution, 3 mm slice thickness. Courtesy of St. Juergen Str, Bremen, Germany



Gradient Echo study acquired in 3:14 min. 512 matrix, 0.4 mm spatial resolution, 3 mm slice thickness. Courtesy of St. Juergen Str, Bremen, Germany



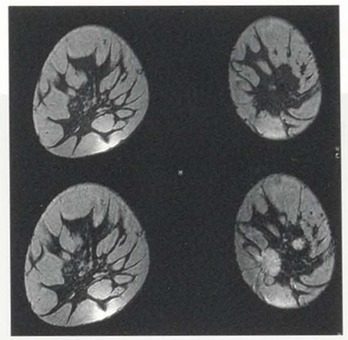
CP Breast Array Coil

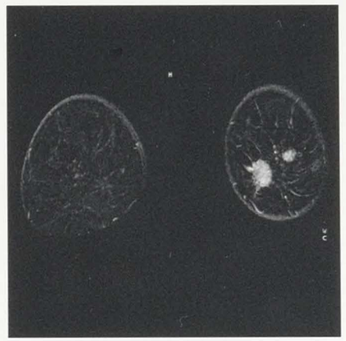
The new CP Breast Array Coil offers high-signal-to noise provided by the circularly polarized coil design. To avoid motion artifacts, the coil has integrated medio-lateral compression plates to stabilize the breast. The transparent window at the top end of the coil allows easy visual control of the position of the breast in the coil.

The CP Breast Array Coil was designed with the comfort of women in mind. Therefore, you will find a variety of cushions to comfort the patient's head and legs while lying in prone position.

The CP Breast Array Coil has the capability to perform fast imaging techniques such as 2D and 3D FLASH with thin slices for high temporal and spatial resolution. Images of the breast can be acquired either both breasts simultaneously or each breast separately. To improve image quality for sagittal single breast images, you can easily switch from left to right coil via software. This offers higher resolution as no additional signal from the other side adds to the image.

- Weight: 7.3 kg
- Size: 530 x 500 mm; height: 145 mm





Dynamic 3D pre- (1 top) and post contrast (bottom) study of the breast. Enhancement can be seen in the post contrast study and is clearly delineated in the subtraction image (left). 512 matrix, 160 x 320 mm FoV, 2 mm slice thickness, 1:31 min acquisition time. Courtesy of AZ St. Jan Brugge, Belgium

:MAGNETOM Jazz:

One year after the introduction of MAGNETOM Harmony and Symphony Siemens is once again proving its concept for the "Perfection of Care" by introducing another highly innovative MR machine the MAGNETOM Jazz.

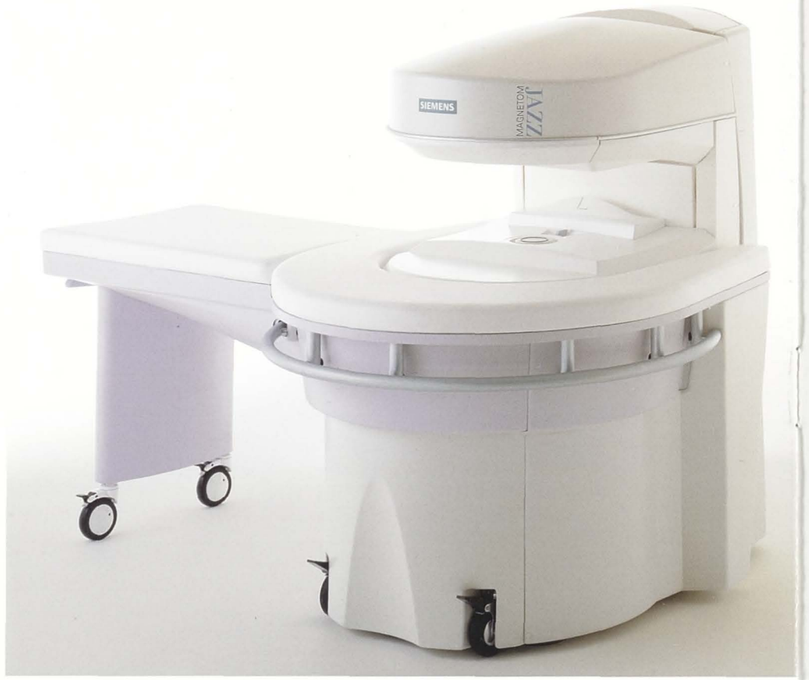
MAGNETOM Jazz is the first open in-office system with focus on orthopedic imaging. It comes complete with a shielding pavilion and can simply be pluged into an existing 110 volt outlet. It is based on a 0.2T permanent magnet featuring 20 mT/m gradients and is equipped with a set of dedicated coils for ankle/foot, knee, wrist and shoulder imaging.

Patient handling is easy due to the ergonomically designed patient table that can be rotated and fixed in six different positions around the center of the magnet. The user interface was specifically designed for the needs of a dedicated system but provides a Numaris look & feel. Imaging techniques include Spin Echo, Turbo Spin Echo, 2D and 3D Gradient Echo for reliable routine orthopedic applications. Its integrated DICOM features make it prepared for all modern teleradiology requirements.

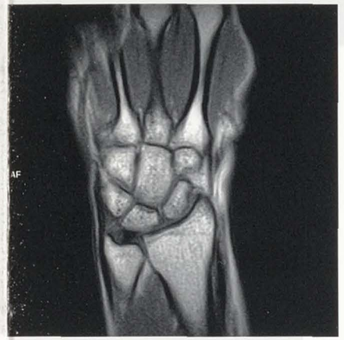
Of course the system comes with all the technical and applications support that one expects from the number one manufacturer of MR machines. As any modern MR systems MAGNETOM Jazz is equipped with a remote diagnostic module, allowing the fast diagnosis of virtually any technical problem that may occur.

Some technical features:

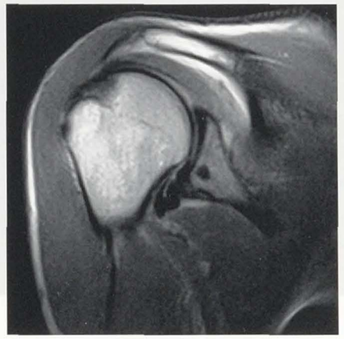
- 0.2 T with 20 mT/m gradients and 0.8 ms rise time
- set of dedicated coils for ankle, foot, knee, wrist and shoulder imaging
- 18 m² (200 square feet or a 13 x 12 ft room)
- no water cooling, no additional air-conditioning
- 1.3 kW power consumption or less than an ordinary vacuum cleaner
- system weighs approx. 2.2 t

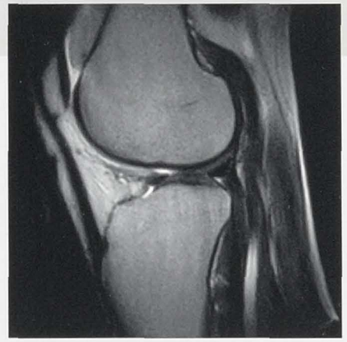


T1 Spin Echo wrist study, TR 560, TE 16, 4 mm slice thickness, 140² mm FoV, 256² matrix.

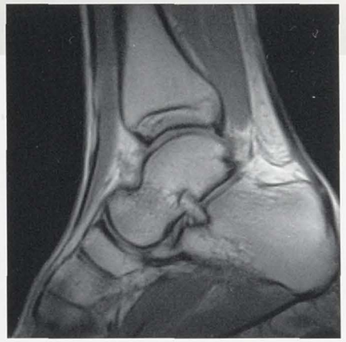


T1 Spin Echo shoulder study, TR 2100, TE 34, 4 mm slice thickness, 200 x 190 mm FoV, 256² matrix.





Turbo Spin Echo knee study, TR 3100, TE 100, 4 mm slice thickness, 180² mm FoV, 256² matrix.



T1 Spin Echo ankle study, TR 630, TE 24, 4 mm slice thickness, 140² mm FoV, 256² matrix.

Meetings and Seminars 1999

For more information about the meetings and symposia please look on the world wide web pages.

M.R.I. National Meeting 1999	May 3-7, 1999	Las Vegas, Nevada	www.edusymp.com/Symposia/symposia.htm
80. Dt. Röntgen-kongress	May 12-15, 1999	Wiesbaden, Germany	www.drg.de
ISMRM '99	May 22-29, 1999	Philadelphia, Pennsylvania	www.ismrm.org/conf.htm
10th Annual Meeting and Postgraduate Course "Portal Hypertension" Europ. Soc. Gastrointestinal and Abdominal Radiology (ESGAR)	June 2-6, 1999	Tübingen, Germany	www.medizin.uni-tuebingen.de/~webradia/esgar/EsgarFrame.htm
CT/MR Technologist SeminarSiemens Medical Systems, Inc.	June 17-19, 1999	Nashville, TN	For info contact Michele McDonald in the US732-321-3270 or email: michele.mcdonald@exchange.sms.siemens.com
4th International Congress on Minimally Invasive Neurosurgery	June 18-20, 1999	Barcelona, Spain	jws-edcc.interscience.wiley.com/cas/calendar.htm
5th International Conference on Functional Mapping of the Human Brain	June 23-29, 1999	Düsseldorf, Germany	www.neurologie.uni-duesseldorf.de/HBM99/
In German only: MTRA: MR Einführungs-, Basis- und Fort-geschrittenenkurs Radiologen, MTRA: MR Angio, Schnelle Sequenzen	Kursdaten auf Anfrage	Switzerland	Contact and more information: Edumed@openoffice.ch

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