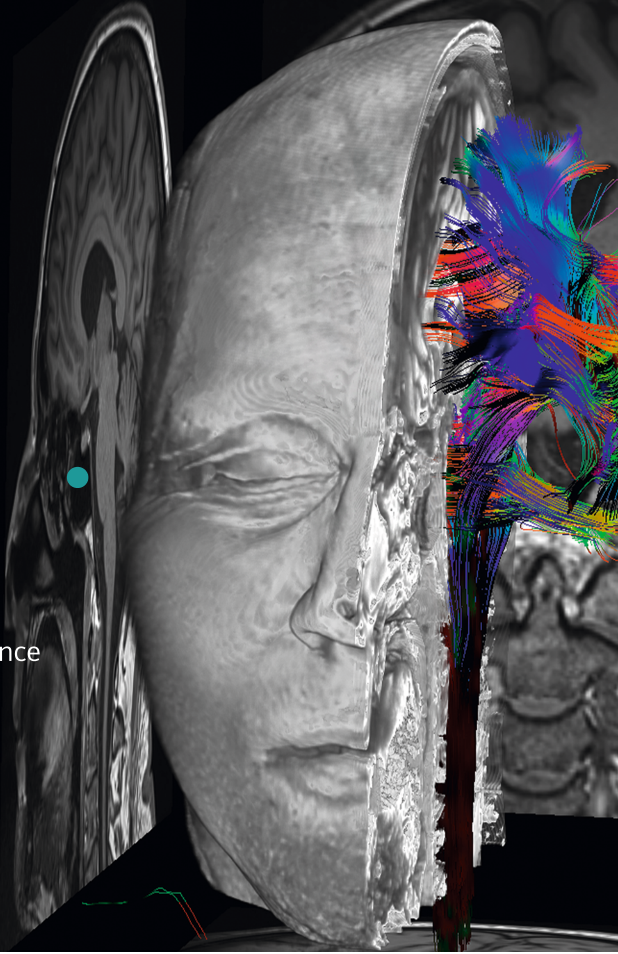
MR Glossary

A Dictionary of Magnetic Resonance



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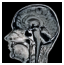
MR Glossary



AC map

→ attenuation correction (AC)

accelerated MRI

MR application: Accelerated MRI comprises the fastest imaging and reconstruction techniques, building upon the foundation of parallel imaging. Accelerated techniques include Simultaneous multislice imaging, Compressed sensing, Deep learning reconstruction.

acquisition

→ data acquisition

acquisition matrix

→ raw-data matrix

acquisition time (TA)

MR measurement: Measurement time for an entire data set. TA does not include the time needed for image reconstruction.

acquisition window

MR measurement: The time frame in a pulse sequence during which the MR signal is acquired.

ACRIN

The American College of Radiology Imaging Network (ACRIN) is a U.S. American cooperative group that performs multi-institutional, interdisciplinary clinical trials of diagnostic imaging and imaging-guided therapeutic technologies.

active shielding (AS)

Magnetic field: For strong magnets, the **stray field** has to be actively shielded to increase the safety zone. For this purpose, secondary compensating coils are wound around the magnet, in opposite direction to the primary field-generating coils.

Gradients: Gradient systems with opposed coils used to reduce **eddy currents**.

active shim

Magnetic field: **Shimming** by adjusting the shim coil currents. Field inhomogeneity, which is partly disturbed by the patient, is improved.

activity-time course

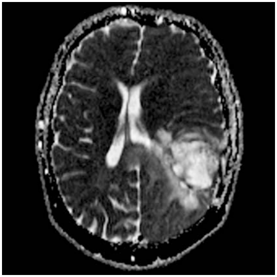
Neuroimaging: The activity-time course is a temporal plot of a given activation task, used in, for example, BOLD evaluations.

adaptive combine

Measurement parameters: Algorithm for combining the channels of **MR signals** from several receiver coil elements. Adaptive combine improves the SNR for most measurement protocols.

ADC map

Diffusion-weighted imaging: Parameter map visualizing the spatially distributed **apparent diffusion coefficients** of the acquired tissue. The contrast does not contain any T1 or T2* contributions. ADC maps can be reconstructed from diffusion-weighted images with at least 2 **b-values**.



aliasing artifact

Image quality: Overfolding artifacts are generated when the measured tissue is outside the FOV but still within the sensitive volume of the coil. Signals from outside the FOV overlap the image, but on the opposite side. Caused by the sampling and subsequent Fourier transform of signal components above the Nyquist frequency.

Remedied primarily through **oversampling**, but regional **presaturation** may be used as well.

alpha image

Postprocessing: An alpha image is a fused image created by overlaying two images with “alpha blending”, that is, manual setting of opacity.
In BOLD imaging, an alpha image is created by overlaying an anatomical image with a parameter map.

analog-to-digital converter (ADC)

MR components: Part of the receiver system which converts the analog MR signal into a digital signal.

apparent diffusion coefficient (ADC)

Diffusion imaging: The apparent diffusion coefficient measures the magnitude of diffusion of water molecules in tissue and is spatially visualized in ADC maps.

array coil

MR components: An array coil combines the advantages of smaller coils (high signal-to-noise ratio) with those of larger coils (large field of view). It consists of multiple independent coil elements that can be combined depending on the requirements of the examination.

→ Tim (total imaging matrix)

array processor

MR components: An array processor comprises multiple computer and storage units, which can be connected in series as well as in parallel, performing a computing task simultaneously. Core of the **image reconstruction system**.

arterial input function (AIF)

Perfusion imaging: Needed to calculate perfusion maps. The arterial input function is taken from the signal time course of the contrast agent concentration in an artery.

arterial spin labeling (ASL)

Perfusion imaging: Arterial spin labeling uses the water in arterial blood as an endogenous contrast agent by marking a specific vessel segment with an RF pulse. By subtracting images with and without markings, statements about the relative blood flow can be made. This technique provides insight into perfusion and the functional physiology of the brain.

artifact

Image quality: Artifacts are signal intensities in an MR image that *do not* correspond to the spatial distribution of tissue in the image plane. They result mainly from physiological as well as system-related effects.

→ **overfolding artifact**

→ **distortion artifact**

→ **flow artifact**

→ **motion artifact**

attenuation correction (AC)

MR-PET examination: The signal of emitted photons is weakened by material or tissue that it has to pass through. For example, coils, the patient table, or the patient weaken the PET signal. Therefore, acquired PET data must be corrected for artifact-free quantitative PET imaging. This is done with specifically postprocessed MR images, so-called *AC maps*. These AC maps are used to create corrected PET images.

AutoAlign (AA)

Slice positioning: Feature that facilitates the workflow for the preparation of an MR scan. The idea of AutoAlign is to assist the user in performing graphical slice positioning for MR examinations, mostly automated and with a reproducible precision in repeated scans, and scans for follow-up examinations.
All MR applications, such as spine, neuro, muscular-skeletal, and cardiac imaging benefit from automatic slice positioning, however, the specific requirements differ between the anatomical regions. Each region may need a specific alignment algorithm. The names for these region-specific AutoAlign features are, for example, AutoAlign Knee, AutoAlign Spine, etc.

autocalibration

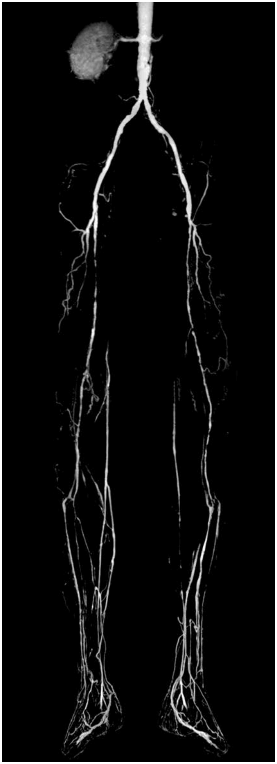
MR measurement: When using Parallel Acquisition Techniques (**PAT**), **coil profile** information, which is required for reconstruction, is obtained by a calibration measurement.

Autocalibration is integrated in the measurement and is both faster (approx. 1 second) and in many cases more exact than a separate calibration. It is performed with sequence characteristics that are identical to those of the acquisition for the current patient position (including possible motions).

automated bolus detection

Contrast-enhanced MRA: Automated functionality that can be activated as part of exam planning.

Automatically detects arrival of contrast bolus in the region of interest and starts arterial-phase measurement.



average

Measurement parameters: Average value of measured signals in a slice used to improve the signal-to-noise ratio (SNR). Averaging is performed, for example, on a measurement with 2 **acquisitions**, that is, number of acquisitions (NA) = 2. The SNR increases with the root mean square of the number of averages.

axial

→ **transverse plane**

bandwidth

Measurement parameters: Frequency range (minimum to maximum processed frequency) used for slice selection (**transmission bandwidth**) or image sampling (**readout bandwidth**).

The bandwidth describes which frequency range from the analyzed echo signal is transferred into one pixel (unit: Hz/pixel).

Increasing the bandwidth allows for shorter echo times and reduces the chemical shift artifacts. The disadvantage of a higher bandwidth is the larger amount of noise which is sampled due to larger frequency range. This translates into a lower signal-to-noise-ratio (SNR).

baseline

MR spectroscopy: Background signal from which the **peaks** rise.

baseline correction

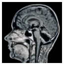
MR spectroscopy: Postprocessing of the spectrum used to suppress baseline deviations from the zero line.

baseline image

BOLD imaging: Nonactivated image, in contrast to activated image, see also **paradigm**.

BioMatrix Technology

MR components: BioMatrix Technology addresses the different aspects of patient biovariability. It comprises three new technologies: BioMatrix Sensors to address patient physiology; BioMatrix Tuners to address patient anatomy; BioMatrix Interfaces to address user interaction with the system and patient in order to accelerate the workflow in the face of patient variability.



biparametric MRI (bpMRI)

MR measurement technique: Biparameteric MRI, e.g. of the prostate, uses an approach without dynamic contrast enhancement (DCE). See also **multiparametric MRI (mpMRI)**

blipped CAIPIRINHA

MR measurement technique: Scheme where the blips in the slice-select gradient are cycled in amplitude to impart a phase on each line of k-space that produces the modulation needed for the **CAIPIRINHA** shift scheme, but does not accrue significant phase over the EPI readout, eliminating "tilted voxel" problem and its spatial resolution filtering effect.

body coil

MR components: The body coil is an integral part of the magnet. It functions as a transceiver coil. It has a large measurement field, but does not have the high signal-to-noise ratio of dedicated coils.

BOLD effect

BOLD imaging: During increased neuronal activity, oxygen concentration increases in the venous blood volume due to locally increased blood flow.

As oxygen increases, the magnetic characteristics of erythrocytes approximate those of the surrounding blood plasma. **Transverse magnetization** in blood vessels decays more slowly. This BOLD effect extends T2 and T2*, measurable as a signal increase in the blood volume under examination.

BOLD imaging

→ **fMRI**

bolus arrival time (BAT)

Contrast-enhanced MRA: Time of contrast arrival in the vessel of interest.

bolus tracking

MR angiography: Technique for visualizing vessels. A small volume of spins is tagged altering its magnetization by injecting contrast agent. This volume of contrast agent (bolus) can be tracked by fast imaging while it moves through blood vessels.

breath-hold technique

MRI measurement technique: To avoid respiratory artifacts, the patients hold their breath during the measurement. Suitable for use in abdominal and cardiac examinations. Not suitable for use with uncooperative patients, small children, or anesthetized patients.

bright-blood effect

Image quality: Brightly displayed blood, as an effect of slow flow. Vascular spins are completely replaced by unsaturated spins during repetition time TR. In gradient-echo sequences, the signal is maximum, and blood is displayed bright in the MR image.

This effect is used in bright-blood imaging of the heart for dynamic display of the blood flow.

b-value

Diffusion imaging: Diffusion-weighting factor (unit: s/mm^2). The higher the b-value, the stronger the diffusion weighting.

B_0 field

MR physics: The static main magnetic field of a magnetic resonance system.

B0 homogenization using gradient enhancement (HUGE)

MR-PET examination: Measurement sequence used in whole-body MR-PET to extend the limited MR FOV so that significant distortion reduction is achieved outside the normal MR-based FOV, and anatomy outside the FOV can be included in reconstruction.

B_1 field

MR physics: The alternating magnetic field of RF radiation generated by a transmit coil.

CAIPIRINHA

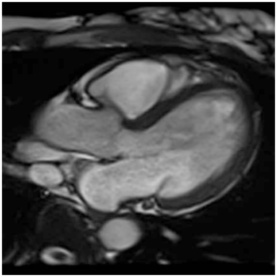
MRI measurement technique: Parallel imaging technique, which modifies the appearance of aliasing artifacts during data acquisition to improve the subsequent parallel image reconstruction procedure (see also PAT). CAIPIRINHA significantly reduces the measurement time of breath-hold measurements without affecting image resolution, coverage, or contrast.

cardiac MRI (CMRI)

MR application: MR imaging technology for non-invasive assessment of the function and structure of the cardiovascular system.

cardiac triggering

Physiologically controlled imaging: Cardiac triggering prevents or reduces motion artifacts in the MR image caused by the heartbeat or pulsating blood flow.



Triggering allows MR images to be acquired synchronized to cardiac movement.

ECG and pulse triggering provide for precise functional examinations of the cardiovascular system and the CSF in the head and spine.
This way, major vessels, the myocardium, and blood flow can be accurately displayed.

Care Bolus

Contrast-enhanced MRA: Care Bolus is the most commonly used bolus-tracking technique. It monitors the arrival of contrast agent in a selected slice in real time and helps to optimize the timing of post-contrast measurements. Bolus tracking is an alternative to the Test Bolus technique.

center

→ windowing

CE MRA

→ contrast-enhanced MR angiography (CE MRA)

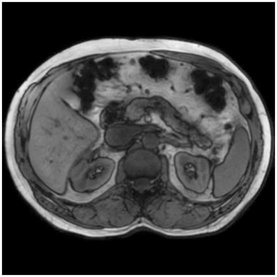
chemical shift

MR physics: Shift in the resonance frequency of an atomic nucleus depending on the chemical bonds of the atom or structure of the molecule. Caused primarily by a weakening of the applied magnetic field by the electron shell, and proportional to the magnetic field strength.

Unit: in ppm (parts per million) of the resonance frequency. The resonance frequencies for fat and water are separated by approximately 3.5 ppm, which corresponds to an absolute frequency difference of about 225 Hz for 1.5 tesla and 450 Hz for 3 tesla.

chemical-shift artifact

Image quality: With gradient-echo sequences, the **chemical shift** may lead to “phase cancellation” in the image. This effect is caused by slightly different **resonance frequencies** of fat and water (approx. 3.5 ppm), which lead to a phase shift in voxels containing fat and water. In an opposed-phase image, fat and water images are shifted mutually. The magnitude of the shift depends on the field strength and the bandwidth.



chemical-shift imaging (CSI)

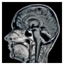
MR spectroscopy: In contrast to **single-voxel spectroscopy**, the CSI methods map the metabolic information from a **volume of interest (VOI)** in a spectral matrix.

cine

→ **movie mode**

circularly polarized coil

→ **CP coil**



CISS sequence

MRI measurement technique: Strongly T2/T1-weighted 3D gradient-echo technique with high resolution, where two acquisitions with different excitation levels are performed internally and are subsequently combined. Prevents streaks, for example, in the inner ear. Postprocessing with MPR or MIP.

coil

MR components: Antennas, called coils in the language of MR, are used to send RF pulses, or to receive MR signals, or both.

As transmit coils, they excite the nuclei in the volume of interest as homogeneously as possible, so that all nuclei receive the same level of excitation.

As receiver coils, they receive the MR signal with as little noise as possible. The signal strength depends among other things on the volume of excitation in the coil and the distance to the object to be measured. The noise, however, depends primarily on the size of the coil.

coil profile

MR physics: Receiver signal characteristics of an **RF coil**, also known as coil sensitivity profile. The strength of the MR signal received from a **voxel** depends on the voxel location relative to the coil. In general, the signal is greatest in the vicinity of the coil. The further away the voxel is from the coil, the weaker the signal.

Coil profiles can be obtained either from a separate calibration measurement or by **autocalibration** integrated in the measurement.

column

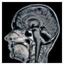
→ **Fourier column**

compressed sensing (CS)

Accelerated MRI: Compressed sensing as part of **accelerated MRI** incoherently under-samples the raw data, reducing acquisition time and producing images with noise-like artifacts. By iteratively reconstructing a sparse representation of the image data, artifact-free images are created.

compressed sensing GRASP-VIBE

Accelerated MRI: Imaging technique for performing dynamic contrast-enhanced 3D imaging in different regions of the body using a radial acquisition scheme similar to that of the StarVIBE sequence. Neither a Test Bolus nor breath-hold commands are necessary. Data is acquired continuously throughout the whole examination while the contrast agent is injected, so timing and synchronization errors cannot occur. See also: **Compressed Sensing**; **StarVIBE**; **GRASP-VIBE**



concatenation

Measurement parameters: Distribution of the slices to be measured over multiple measurements. Possible applications:

- For a short TR, increase the number of concatenations to be able to measure more slices.
- To prevent crosstalk when the slice distance is short, set concatenations to 2 and measure the slices in an interleaved fashion.

continuous arterial spin labelling

Perfusion imaging: In continuous arterial spin labelling (CASL), the blood water is inverted as it flows through the brain in one plane. CASL is characterized by one single long pulse (around 1-3) seconds. See also: ASL

contour artifact

→ chemical-shift artifact

contrast agent

Image quality: Chemical compounds that are used to improve contrast.
MRI examinations typically use paramagnetic contrast agents such as gadolinium DTPA or other Gadolinium compounds.

In contrast to X-ray techniques, where contrast agent is directly visible, in MRI, contrast agents only have an indirect effect as they reduce the relaxation times for water in tissue.

contrast bolus

MR angiography: A small volume of spins, which are tagged by a contrast agent, propagating through a vessel. Used for **bolus tracking**.

contrast-enhanced MR angiography (CE MRA)

MR application: Contrast-enhanced MR angiography makes use of the T1 reduction of blood by means of gadolinium-based contrast agents. CE MRA is not limited by saturation effects, therefore, large measurement fields and all orientations are possible.

contrast medium

→ **contrast agent**

contrast-to-noise ratio (CNR)

Image quality: The contrast-to-noise ratio in an MR image is the difference in the signal-to-noise ratios between two tissue types, *A* and *B*.

$$CNR = SNR_A - SNR_B$$

coronal plane

Slice orientation: Orthogonal plane dividing the body into back (dorsal, posterior) and front (ventral, anterior) parts.

coronary MR angiography (cMRA)

MR application: A developing approach to imaging the coronary arteries.

CP coil

MR components: Circularly polarized transmit or receiver coil with two orthogonal transmission or receiver channels, or both. A CP coil has a better signal-to-noise ratio than a linearly polarized coil.

CPR

→ curved planar reconstruction (CPR)

cross calibration

MR-PET examination:
To ensure reliability of the PET data, a correlation with some external measure of radioactivity is required. In research settings, the external measuring device may be a well counter; in clinical PET, a dose calibrator is used.

crosstalk

Image quality: If slices distances are too small, the signals from adjacent slices affect one another, especially when the slice distance equals 0. Crosstalk is caused by a non-ideal slice profile which results from constraints of the measurement technology. Crosstalk also affects T1 contrast.

Crosstalk can be avoided by using an **interleaved** slice sequence.

cryogen

Magnet technology: Cooling agent such as liquid helium or nitrogen. In MR, cooling agents are used to maintain the superconductivity of the magnet.

curved planar reconstruction (CPR)

Postprocessing: CPR is similar to MPR, but can generate planar cross-sections through volume data that are orthogonal or tangential to a user-defined curve along an anatomic structure.

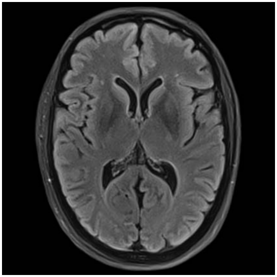
dark blood

Cardiac imaging: Special preparation pulse that saturates the blood, used for displaying cardiovascular anatomy.

dark-fluid imaging (FLAIR)

MRI measurement technique: For example T2 FLAIR, is a **turbo inversion recovery** technique with long **effective echo time** and long **inversion time** for suppressing fluids. Lesions are not visible with conventional T2 contrast, because they are covered by bright-fluid signals.

However, with the dark-fluid technique, lesions can be made visible. The inversion pulse is applied in a such a way that the T1 relaxation of the fluid reaches zero crossing at time point TI, which results in the signal being "erased".



dark-lumen MR colonography

MR measurement technique: MR colonography imaging technique that involves the administration of water, carbon dioxide, room air, or fat.

data acquisition

MR measurement: Process of collecting raw image data from MR signals. To improve the **signal-to-noise ratio** in an image, several acquisitions can be performed to image a slice. Examples for data acquisition techniques: **CISS**, **CAIPIRINHA**, **DESS**, **FISP**, etc.

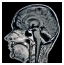
dB/dt

Safety: The ratio between the amount of change in amplitude of the magnetic field (dB) and the time it takes to make that change (dt); depends on the gradient system. Because changing magnetic fields can induce electrical fields, this is one area of potential concern for MRI safety limits (see also **peripheral nerve stimulation**).

The value of dB/dt is measured in tesla per second (T/s).

dedicated coil

→ **local coil**



Deep learning (DL) reconstruction

Accelerated MRI: Deep learning as a subfield of machine learning uses artificial neural networks with many hidden layers (“deep networks”). The deeper the network, the more sophisticated the internal pattern searching can become. The networks have to be trained in order to perform their desired function. Deep learning reconstruction is the application of deep learning for MR image reconstruction.

Deep Resolve

Accelerated MRI: Deep Resolve algorithms use **Deep learning reconstruction**. They are designed to accelerate acquisition and improve image reconstruction in all body regions and almost every diagnostic procedure.

Deep Resolve Boost

Accelerated MRI: Deep Resolve Boost is a reconstruction technique to radically shorten scan time without compromising image resolution. The technique uses raw-data-to-image deep learning reconstruction. The result is strong denoising in highly accelerated data.

Deep Resolve Gain

Accelerated MRI: Deep Resolve Gain delivers particularly strong and targeted denoising for fast acquisitions. The technique uses raw data from a reduced, and thus faster scan as input. Simultaneously with the raw data individual noise maps are acquired which reflect local noise variations.

Deep Resolve Sharp

Accelerated MRI: Deep Resolve Sharp improves image quality by increasing the sharpness and reducing Gibbs ringing around edges, in shorter scan time. To ensure consistency and robust results the reconstructed image is cross-checked with the original raw data.

Deep Resolve Swift Brain

Accelerated MRI: Acquisition method that provides a set of fast multi-shot EPI protocols to acquire all clinically relevant contrasts required for routine and emergency brain examinations in approximately two minutes. For T2, T2*, and FLAIR contrasts, multi-shot acquisitions with **deep learning image reconstruction** are used.

defocusing

→ **dephasing**

dephasing

MR physics: After RF excitation, phase differences appear between precessing spins, resulting in a decay of **transverse magnetization**. Caused primarily by spin-spin interaction and inhomogeneity in the magnetic field, can also be caused by switching specific gradient fields (**flow dephasing**).

→ **rephasing**

DESS sequence

MRI measurement technique: DESS is a 3D gradient-echo technique where two different gradient echoes (**FISP sequence** and **PSIF sequence**) are acquired during repetition time TR. During image reconstruction, the strongly T2-weighted PSIF image is added to the FISP image. Application: joints, good contrast for cartilage. Postprocessing with **MPR**.

deviation map

Neuroimaging: Brain morphometry results are visualized as deviation maps and label maps. The deviation map shows the different brain regions, color-coded to indicate the degree of deviation from the average age- and gender-matched normative volume. The color range (from green to red) is based on the standard deviation. No deviations or minor deviations are shown in green, large deviations in red.

diamagnetism

MR physics: Effect resulting in a slightly weakened magnetic field when a substance is introduced into it. Magnetization of a diamagnetic material is opposite to the main magnetic field. The material is considered to have a negative magnetic **susceptibility (magnetizability)**.

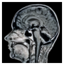
DICOM

Standard for electronic data exchange of medical images.

The DICOM standard enables the transfer of digital medical images and corresponding information, independent of device and manufacturer.
In addition, DICOM provides an interface to hospital systems based on other standards.

diffusion

Physics: Process by which molecules or other particles move from areas of higher concentration to areas of lower concentration. When concentrations are equal, there is a statistical balance, even though the molecules are constantly subject to thermal movement (Brownian molecular movement).



diffusion contrast

Diffusion imaging:
The diffusion of water molecules along a field gradient reduces the MR signal. The behavior is exponential:

Signal = $S_0 \exp(-b\ D)$

In areas of low diffusion (pathological tissue), signal loss is less intense. These areas are shown brighter in the diffusion-weighted image.

diffusion direction

Diffusion imaging: Diffusion-weighted measurements are performed in different directions. The number of diffusion directions depends on the diffusion mode and can be selected by the user.

diffusion map

→ ADC map

diffusion spectrum imaging (DSI)

MR application: DSI is a variant of diffusion-weighted imaging, which makes it possible to resolve fine anatomical details of the brain, such as crossing white-matter fibers, by using multiple diffusion directions and b-values in a single measurement.

diffusion tensor

Diffusion imaging: Physical magnitude which takes into account the directional dependency of diffusion.
The diffusion tensor displays the mobility of water molecules in all three coordinates.
The tensor data are used as the basis for computing additional maps (for example: **FA map**) or **diffusion tractography**.

diffusion tensor imaging (DTI)

MR application: Method for displaying the directional dependency of diffusion.
Application: examinations involving the architecture, configuration, and integrity of nerve fiber bundles (neurological research).

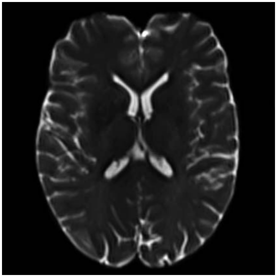
diffusion tractography

Diffusion tensor imaging: Method for displaying neural pathways (diffusion tracts) using diffusion tensor measurements.

Tractography supports the planning of operations and supports neurophysiological research regarding the connectivity and pathology of white matter.

diffusion-weighted imaging (DWI)

MR application: MR imaging is sensitive to motion and flow and to the relatively low diffusion effect (visualized with strong gradients). Diffusive movements in tissue (for example: natural diffusion of water) reduce the signal.



Of interest are regions where diffusion is reduced compared with its surroundings (such as cell membranes along white matter tracts, or in areas of the brain affected by stroke). Reduced diffusion means the reduction in signal is less intense: the affected regions are displayed brighter in the diffusion-weighted image.

diffusion-weighting factor

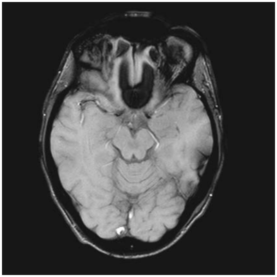
→ b-value

Displacement Encoding with Stimulated Echoes (DENSE)

Cardiac imaging: Functional cardiac MRI pulse sequence used to create maps of myocardial displacement with high resolution. The DENSE magnitude images produce black blood images to show better myocard-blood contrast and to reduce motion artifacts.

distortion artifact

Image quality: Image distortions are caused by inhomogeneity in the magnetic field, gradient non-linearity, or ferromagnetic materials in proximity to the examination.

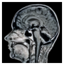


Dixon technique

MRI measurement technique: Dixon is a technique for separating fat and water. For this purpose, the technique uses the different **resonance frequencies** of fat and water protons (**chemical shift**). Essentially an **in-phase** and an **opposed-phase image** are measured.

By adding the in-phase and opposed-phase, pure **water images** are generated while pure **fat images** are generated through subtraction.

As compared to spectral fat saturation, a high field homogeneity is less important for Dixon.



double-echo sequence

MRI measurement technique: Sequence with two echoes. In addition, **proton density weighted images** are generated without increasing the measurement time. They are produced from the first echo of a T2-weighted double-echo sequence.

double inversion recovery (DIR)

MRI measurement technique: Double inversion recovery MRI employs two non-selective inversion pulses in order to suppress the signal from two tissues with different longitudinal relaxation times T1 simultaneously. In the brain, DIR is used to image the gray matter selectively by nulling the signal from white matter and cerebrospinal fluid (CSF). See also **inversion recovery**.

double-oblique slice

Slice positioning: Obtained by rotating an **oblique slice** about one axis in the image plane.

dual-contrast sequence

MRI measurement technique: Example: Dual-contrast with echo sharing.

TSE counterpart to double-echo sequences, generally 5 times as fast.

To keep the pulse train as short as possible, only echoes for PD- and T2-weighted images where the phase-encoding gradient has a small amplitude are measured separately.

The echoes that determine resolution are used in both raw-data matrices (**echo sharing**). This reduces the number of echoes required. More slices can be acquired for the TR specified, and the RF stress (SAR) drops.

dual mode

Ultra-high field imaging: Functionality that allows users to switch between research mode (**pTX** mode) and clinical mode (**1Tx mode**), with its clinically validated protocols, in less than 10 minutes.

duty cycle

→ **gradient duty cycle**

ECG triggering

Physiologically controlled imaging: ECG triggering synchronizes the measurement with the cardiac signal of the patient. The R wave is used as a trigger. This method is particularly useful for measurements of the heart or thorax. Otherwise, images may be blurred due to cardiac contractions.

echo

MR physics: An echo is the refocusing of spin magnetization by a pulse of resonant electromagnetic radiation.

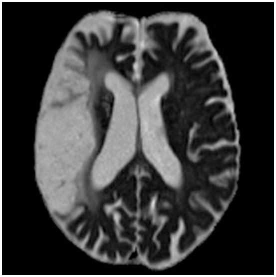
The MR signal observed following an initial excitation pulse decays with time due to both spin relaxation and any inhomogeneous effects which cause different spins in the sample to precess at different rates.

→ gradient echo (GRE)

→ spin echo (SE)

echo-planar imaging (EPI)

MRI measurement technique: A fast imaging method that acquires multiple k-space lines following a single excitation. Most commonly acquiring data for an entire 2D image (“single-shot” EPI).



echo sharing

MRI measurement technique: For dual-contrast or higher time-resolved sequences. Echoes are used in more than one raw-data matrix.

echo spacing

Measurement parameters: Distance between two echoes. Echo spacing is used in TSE or EPI sequences, for example. A short echo spacing produces compact sequence timing and less image artifacts.

echo time (TE)

Measurement parameters: The time between the excitation pulse of a sequence and the resulting echo, which is used as MR signal. Determines image contrast.

echo train

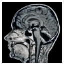
Multiecho sequences: A series of 180° RF rephasing pulses and their corresponding echoes for a fast or turbo spin echo pulse sequence.

eddy current

Image quality: Electrical currents generated in a conductor by changing magnetic fields or by a movement of the conductor within the magnetic field. Can be reduced using shielded gradients. Eddy currents are a source of artifacts.

edge oscillation

→ truncation artifact



effective echo time (TE_{eff})

Measurement parameters: The contrast and signal-to-noise ratio of an MR image are determined, among others, by the temporal position of the echo whose phase-encoding gradient has the smallest amplitude (corresponds to the central k-space line). In this case, the echo signal undergoes minimal dephasing and has the strongest signal.
The effective echo time is the time between the excitation pulse and this echo.

effective repetition time (TR_{eff})

Physiologically controlled imaging: In prospective cardiac triggering, the repetition time TR is predetermined by the interval between the trigger events. Therefore, TR cannot be freely set. The effective repetition time TR_{eff} established by the trigger interval fluctuates with the physiological rhythm.

effective stimulus duration (tseff)

Safety: Duration of any period of the monotonic increasing or decreasing gradient, used to describe its limits for cardiac or peripheral nerve stimulation.
It is defined as the ratio of the peak-to-peak field variation and the maximum value of the time derivative of the gradient during that period.

elastogram

MR elastography: Relative stiffness map calculated from wave image in **magnetic resonance elastography** and then compared with the anatomical image to highlight stiffness in the tissue.

electromagnetic induction

Physics: The electrical voltage in a receiver coil created by a temporal change in the magnetic field.

EPI factor

Echo-planar imaging:
Number of gradient echoes of an EPI sequence acquired after a single excitation pulse (typically 64 to 128).
For example, EPI factor 128 results in a measurement time that is 128 times faster than that of a normal gradient-echo sequence.

EPI technique

→ **echo-planar imaging (EPI)**

Ernst angle

Measurement parameters:
The **flip angle** (< 90°) of a gradient-echo sequence where a tissue type with a specific T1 generates the maximum signal. Depends on the repetition time TR.

$\alpha_{Ernst} = \arccos(e^{-TR/T1})$

event

MR-PET examination:
An event refers to the positron annihilation event. The positron emitted by the radioactive tracer travels through tissue, decelerating until it can interact with an electron.
This encounter annihilates the electron and positron, producing a pair of annihilation (gamma) photons moving in approximately opposite directions.
The technique depends on simultaneous or coincident detection of the pair of photons moving in approximately opposite direction. Types of events are **true**, **random**, and **scatter** events.

excitation pulse

MRI measurement technique:
Rotation of magnetization out of alignment with the longitudinal axis, caused by the application of an RF pulse. The higher the energy of an excitating RF pulse, the greater the deflection of the net magnetization. The deflection of the magnetization at the end of the RF pulse is known as the **flip angle**.

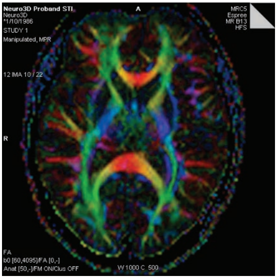
FA map

Diffusion imaging: An FA (fractional anisotropy) map displays the degree of anisotropy of the diffusion relative to the average overall diffusion.

Isotropic diffusion: Water molecules move the same way in every direction.

Anisotropic diffusion: Water molecules clearly move in a preferred direction.

Isotropic diffusion is displayed dark, anisotropic diffusion is displayed bright. The color encodes the orientation of diffusion. The FA map is one of the **parameter maps** for **diffusion tensor imaging**.



fast Dixon

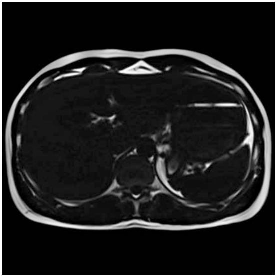
MRI measurement technique: A dual-echo Dixon technique where in- and opposed-phase echoes are acquired consecutively within one echo train, providing reduced sensitivity to motion. An asymmetric echo mode is possible, increasing the distance between in- and opposed-phase echoes. See also **Dixon technique**.

fast Fourier transform (FFT)

Image reconstruction: Algorithm for fast MR image reconstruction from raw data.

fat image

Image quality: A pure fat image displays only the signals from fat protons in the image and suppresses signals from water protons. Fat images are generated with the **Dixon** technique, for example. See also **water image**.



fat saturation (FatSat)

Image quality: To suppress the fat component in the MR signal, fat protons are saturated by frequency-selective ("spectral") RF pulses. Fat saturation depends on the **chemical shift** between fat and water of approx. 3.5 ppm. Spectral fat saturation is sensitive to magnetic-field inhomogeneities.

→ **presaturation**

fat suppression

Image quality: The MR signal comprises the sum of signals from water and fat protons. Various techniques can be used to suppress the fat signal.

→ **Dixon technique**

→ **STIR sequence**

feet first

Positioning: The patient is positioned *feet first* in the magnet bore.

ferromagnetism

Physics: Effect where a material, for example, iron, is drawn toward a magnetic field. Relevant to safety for MR imaging.

FID signal

MR physics: Signal that is induced by the RF excitation of the nuclear spins and that decreases exponentially without external influence at a characteristic time constant T2*.

field map

Neuroimaging: A field map displays local distortions and local signal loss in the images resulting from the measurement technique used to acquire the images. The field map masks areas where functional information is ambiguous.

field of view (FOV)

Measurement parameters: Square image area to be measured (in mm × mm). For a fixed matrix size, the spatial resolution increases with a smaller field of view, because of smaller **voxels** (pixel size = FOV/matrix). However, smaller voxels yield lower signals.

field strength

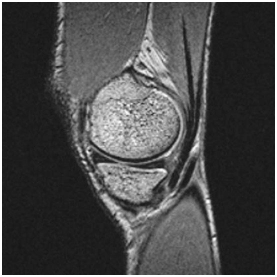
→ **magnetic field strength**

first pass

Contrast-enhanced MRI: Passage of the intravenously injected contrast agent bolus through the right ventricle and the lungs to the left ventricle and myocardium.

FISP sequence

MRI measurement technique: With the FISP gradient-echo sequence, the remaining transverse magnetization is not eliminated before the next RF pulse. Instead, it contributes to the signal along with the longitudinal magnetization. The strength of the longitudinal magnetization depends on T1; the amplitude of transverse magnetization depends on T2*. Contrast is a function of T1/T2* and is generally not dependent on TR.

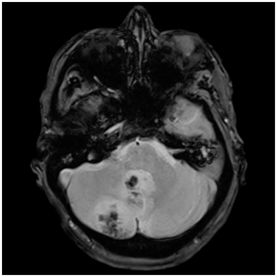


FLAIR technique

→ dark-fluid imaging (FLAIR)

FLASH sequence

MRI measurement technique: The FLASH gradient-echo sequence uses the equilibrium of longitudinal magnetization. The remaining transverse magnetization is eliminated by a strong gradient (**spoiler gradient**). T1-weighted and T2*-weighted contrast can be set with the FLASH sequence.



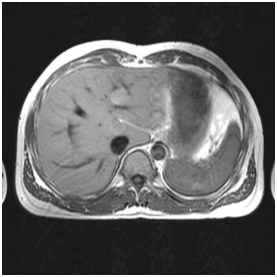
flip angle

Measurement parameters: The flip angle a is used to define the angle of excitation for a pulse sequence.
It is the angle to which the net magnetization is rotated relative to the main magnetic field direction via the application of a RF excitation pulse at the Larmor frequency.

Flip angles between 0° and 90° are typically used in gradient-echo sequences, 90° and a series of 180° pulses in spin-echo sequences and an initial 180° pulse followed by a 90° and a 180° pulse in inversion recovery sequences.

flow artifact

Image quality: Motion artifacts caused by local signal changes during a measurement. For example, the inflow intensity of a vessel perpendicular to the image plane changes periodically due to pulsatile blood flow. In transverse body images, for example, ghost images appear in the aorta. Nonperiodic inflow enhancement as it occurs with the turbulent blood flow in the heart results in smearing artifacts in the image.



flow compensation

MRI measurement technique: To override the signal loss caused by spin movement, both moved and unmoved spins can be rephased. For this purpose, gradient pulses of a suitable size and duration are switched.

→ gradient motion rephasing (GMR)

flow dephasing

MRI measurement technique: Exclusion of signals from flowing substances such as blood by applying specifically applied gradient fields that dephase moving spins while maintaining the signal of stationary spins.

→ dephasing

flow effect

Image quality: Flow effects play two conflicting roles in MR imaging:

- They are a source of undesired image artifacts

→ flow artifact

- In MR angiography, they are used to display blood vessels and to provide quantitative information on the velocity of the blood flow.

→ bright-blood effect

→ jet effect

→ signal elimination

→ wash-out effect

flow encoding

MRI measurement technique: Use of phase-encoding or other techniques intended to obtain information regarding the direction and velocity of moving material.

flow quantification

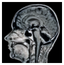
MR application: Quantitative flow measurements that use phase contrast to examine pathologies in large vessels or as part of an extensive cardiovascular MRI examination. Flow measurements allow for noninvasive evaluation of the blood flow.

flow rephasing

→ rephasing

Flow-sensitive Alternating Inversion Recovery (FAIR)

Functional imaging: Blood-flow measurement technique for generating perfusion-based functional images by subtracting two acquired IR (inversion recovery) images, one with a non-slice-selective inversion pulse and another with a slice-selective inversion pulse.



flow sensitivity

Phase-contrast angiography: The flow sensitivity of a phase-contrast sequence refers to the flow velocity where the phase difference between flow-compensating and flow-encoding scans is 180 degrees. See also **velocity encoding**.

fluid-attenuated inversion recovery

→ **dark-fluid imaging (FLAIR)**

fluorodeoxyglucose (FDG)

MR-PET examination: Fluorodeoxyglucose, commonly abbreviated to ^{18}F-FDG or FDG, is a radiopharmaceutical used in positron emission tomography (PET). Chemically, it is a glucose analog, with the positron-emitting radioactive isotope fluorine-18 substituted for the normal hydroxyl group in the glucose molecule. After FDG is injected into a patient, an MR-PET scanner can form images of the distribution of FDG in the body.

→ **tracer**

fMRI

Functional MRI uses magnetic properties of blood to analyze brain activity in specific areas. The technique is based on small changes in the blood flow and is referred to as BOLD imaging.

Fourier column

Measurement parameters: In the raw-data set (k-space), the rows of the **raw-data matrix** represent the **phase-encoded** portion of the measured signals.

Fourier line

Measurement parameters: In the raw-data set (k-space), the columns of the raw-data matrix represent the frequency-encoded portion of the measured signals.

Fourier space

→ k-space

Fourier transform (FT)

Imaging: Mathematical procedure for reconstructing images from raw data.

MR spectroscopy: Method for calculating MR spectra from time-resolved MRI data.

FOV

→ field of view (FOV)

fractional anisotropy map

→ FA map

Fractional MR Elastography

MR application: A variant of the standard MR Elastography protocol, Fractional MRE is only used for patients with a very short T2* relaxation time whose resulting signal is too low. Using Fractional MRE reduces the duration of the motion-encoding gradient (MEG) to a fraction of the full wavelength.

frame of reference (FOR)

DICOM standard: The frame of reference controls compatibility of images within a series and in relation to other series. Series with identical FOR belong to the same coordinate system and are compatible.

free induction decay signal

→ **FID signal**

frequency

Physics: The number of repetitions of a periodic process per unit of time (unit: hertz).

frequency adjustment

MR measurement: Setting the RF system frequency to the **resonance frequency** of the main magnetic field (**Larmor frequency**).

frequency encoding

MR measurement: During data acquisition, a magnetic field gradient is applied in one spatial direction providing nuclear spins with linearly increasing precessional frequencies. The readout MR signal is a mix of all these frequencies. These various frequencies can be filtered individually. In the row direction, the location of the nuclear spin can be reconstructed from the frequency.

This axis is called the frequency-encoding axis.

The perpendicular axis to it is the direction of the **phase encoding**.

frequency scout

Cardiac imaging: Fast low-resolution images obtained at different resonance frequencies.

fringe field

→ stray field

frontal plane

→ coronal plane

functional imaging

As opposed to imaging the anatomy and morphology of parts of the body and organs, functional imaging visualizes physiological activities such as the myocardial function of the heart.

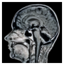
For functional neuroimaging see fMRI.

functional magnetic resonance imaging

→ fMRI

fusion

Postprocessing: Fusion mode is a function for image fusion of multiple 2D/3D data sets with alpha blending, that is, overlay of two images and setting the opacity manually.



gadolinium DTPA

Contrast agent: The uptake of gadolinium-containing contrast agent reduces the T1 and T2 values of tissues, depending on the concentration. The T1 effect is the more relevant in clinical routines.

gating

Physiologically controlled imaging: Synchronization of imaging with a time window so that a particular event or signal from among many will be selected and others will be eliminated or discarded.
A variety of means for detecting these time windows can be used, such as the ECG, peripheral pulse, and chest motion (see also PMU).
The synchronization can be prospective or retrospective.

gauss

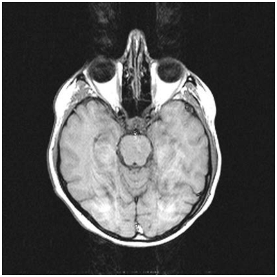
MR physics: Old unit for magnetic field strength. Today, the unit tesla (T) is used (1 tesla = 10 000 gauss).

general linear model

→ GLM

ghost image

Image quality: During movement such as breathing, some phase-encoding steps are acquired during inspiration (for example: inspiration phase), and others during expiration (for example: expiration phase). This quasi-periodic misencoding results in a displaced false image of the body region.



Signal-rich structures such as subcutaneous fat are particularly susceptible to ghost images due to movement. The distance between the ghost images depends on the movement period and relaxation time TR.

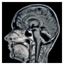
In echo-planar imaging, ghost images may occur at a distance of half the FOV.

Gibbs artifact

→ truncation artifact

GLM

BOLD imaging: GLM calculates BOLD images by adjusting a linear combination of different signal portions. In addition, interferences such as slow signal fluctuation are successfully suppressed and reliable activation maps are obtained. GLM also allows a detailed evaluation of the measurement data.



global bolus plot (GBP)

→ global time-intensity curve

global shim

Magnetic field: For several techniques such as fat saturation, EPI or spectroscopy, especially high magnetic field homogeneity is required.
In this case, shim coils can be used to optimize homogeneity.

global time-intensity curve

Perfusion imaging: Diagram for evaluating successful bolus transport.

gradient

MR physics: A gradient defines the strength and orientation of a magnitude changing in space. A magnetic field gradient is a change in the magnetic field of a certain orientation, a linear increase or decrease. The magnetic gradient fields are generated with **gradient coils**.
They determine the spatial resolution in an image, for example.

gradient coil

MR components: Coils used to generate magnetic gradient fields. Gradient coils are operated in pairs in the magnet, at the same current, however, of opposite polarities.

One of the coils increases the static magnetic field by a certain amount, the opposite coil reduces it by the same amount. This changes the magnetic field overall. The change is the linear **gradient**.
According to the coordinate axes, there are x, y, and z gradient coils.

gradient duty cycle

Gradient technology: Time permitted during which the gradient system can be run at maximum power. It is based on the total time (in %), including the cool-down phase.

gradient echo (GRE)

MR physics: Echo created by switching a pair of dephasing and rephasing gradients, without a rephasing 180° pulse as with the spin-echo technique.

gradient field

→ gradient

gradient motion rephasing (GMR)

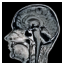
MRI measurement technique: A method for achieving flow compensation. Additional gradient pulses of a suitable size and duration are switched. They correct for phase shifts experienced by moving spins, thus reducing flow artifacts.

gradient offset

Gradient technology: Gradient offsets are used to compensate linear magnet inhomogeneities by current offsets applied to the different gradient axes (first order shim).

gradient rise time

Gradient technology: The time required by the gradient field to rise from zero to the maximum value.



gradient slew rate

Gradient technology: Gradient field increase by unit time (unit: T/m/s).

Slew rate = gradient strength/ rise time

gradient strength

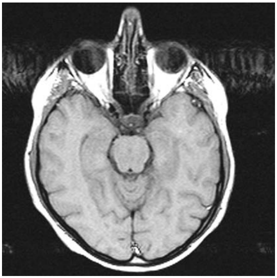
Gradient technology: Amplitude of the gradient field, measurement unit mT/m (millitesla per meter).

gradient swap

Measurement parameters: Exchange of phase-encoding and readout directions in the image. As a result, interfering flow and motion artifacts are rotated by 90°. Prevents artifacts from covering structures of interest.

gradient system

MR components: In order to precisely localize the requested slice positions in MR imaging, the gradient system, consisting of three sets of **gradient units** (one for each direction), creates defined pulsed alterations of the main magnetic field, referred to as **gradients**. For example, a whole-body gradient system is suitable for use in whole-body MR equipment.



gradient unit

MR components: All gradient coils and amplifiers that together generate a magnetic field gradient along *one* of the axes of the coordinate system of the MR equipment.

graphical slice positioning (GSP)

Slice positioning: Graphical positioning of the slices and saturation regions to be acquired on localizer images. Relevant measurement parameters may be conveniently adjusted on-screen via the mouse.

GRAPPA

MRI measurement technique: Further development of SMASH with autocalibration and a modified algorithm for image reconstruction.

GRASE

MR measurement technique: Hybrid technique that generates and records a series of alternately acquired gradient echoes and spin echoes from a train of RF-pulses.

GRASP

MR measurement technique: Iterative reconstruction technique for dynamic contrast-enhanced (DCE) MRI based on a radial stack-of-stars k-space trajectory. Data is acquired continuously throughout the whole exam while the contrast agent is injected. GRASP examinations can be performed during free breathing, dispensing with the need for breath-hold commands.

GRASP-VIBE

MR measurement technique: Motion-insensitive VIBE sequence that supports free-breathing measurements. Can be used for dynamic contrast-enhanced (DCE) 3D imaging in different regions of the body using the radial acquisition scheme of the StarVIBE sequence.

grid tagging

Cardiac imaging: Technique of myocardial tagging, applying a grid of saturation lines across cardiac MR images. Used to view myocardial motion.

GSP

→ graphical slice positioning (GSP)

half-Fourier matrix

MRI measurement technique: The raw-data matrix has a specific symmetry which theoretically makes sampling of only half the matrix sufficient. The other half can be symmetrically reconstructed; mathematically, the matrices are *conjugate complex*.

However, unavoidable phase errors due to minor magnetic field inhomogeneity require a phase correction. For this reason, slightly more than half of the raw data are acquired. Measurement time is reduced by just under 50 %.

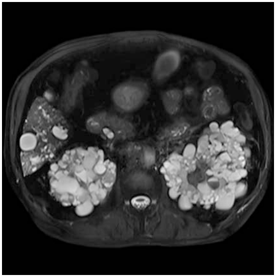
Hamming filter

Type of raw-data filter

HASTE technique

MRI measurement technique: HASTE is a turbo spin-echo technique and is used for sequential acquisition of high-resolution T2-weighted images.

All image information is obtained after a single excitation pulse. Echoes are generated by subsequent 180° pulses. The image is obtained after a half-Fourier reconstruction.



head coil

MR components: Volume coil suitable for MRI examination of the patient's head.

head first

Positioning: The patient is positioned *head first* in the magnet bore.

head SAR

Safety: Specific absorption rate (SAR) averaged over the mass of the patient's head and over a specified time.

hertz

Physics: SI unit of frequency (1 Hz = 1 s^{-1}).

HIPAA

The Health Insurance Portability and Accountability Act (HIPAA) was enacted by the United States Congress and sets the standard for protecting sensitive patient data.

homogeneity

Image quality: A magnetic field is considered homogeneous when it has the same field strength across the entire volume. With MR, the homogeneity of the static magnetic field is an important criterion for magnet quality. High homogeneity is important for spectral **fat saturation**, a large **field of view (FOV)**, **off-center imaging**, **echo-planar imaging**, and **MR spectroscopy**.

hybrid spectroscopy

MR application: Combination of **single-voxel spectroscopy** and **chemical-shift imaging**. The CSI measurement is performed across a selectively excited volume of interest. Via volume selection, areas with strong distorting signals (for example: fat) are not stimulated. For this reason, they do not contribute signal to the spectra.

iGRASP

MR measurement technique: Iterative goldenangle radial sparse parallel MRI (iGRASP) combines compressed sensing, parallel imaging, and golden]angle radial sampling to allow fast and flexible free]breathing dynamic volumetric MR imaging e. g. of the liver.

image contrast

Image quality: The contrast in the image is the relative difference in the signal strength between two adjacent tissue types.
It depends primarily on the existing tissue parameters (**T1**, **T2**, **proton density**), as well as flow, diffusion, etc.

Contrast can be affected by the sequence used (**spin echo**, **inversion recovery**, **gradient echo**, **TSE** etc.), the measurement parameters (**TR**, **TE**, **TI**, **flip angle**) and the use of **contrast agent**.

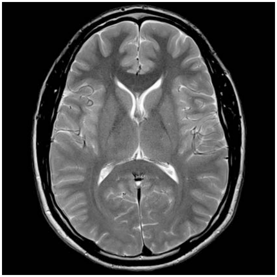


image filter

Measurement parameters: During measurement, the image filter is used to set the intensity, edge enhancement, and smoothing.

Reconstruction parameters: Filters of various strengths (strong, medium, soft) can *subsequently* be applied to MR images to reduce noise. High-pass and low-pass filters are used with different shapes to the characteristic curves. Other filter types include smoothing filters, for example.

image fusion

→ **fusion**

image matrix

Image display: The MR image consists of a multitude of picture elements (**pixel**). Pixels are allocated to a matrix in a checkered pattern. Every pixel in the image matrix displays a specific gray scale level. Viewed as a whole, the matrix of gray levels constitutes the image.

Not to be confused with a **measurement matrix**.

image noise

Image quality: Noise in the image is a statistical fluctuation in signal intensity that does not contribute to the image information. It appears in the image as a granular, irregular pattern. In principle, the effect is unavoidable and is physically based. The noise of the image is a function of the field strength, coil size (body coil, local coil, array coil), the pulse sequence used, and the **spatial resolution**.

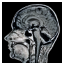


image orientation

→ slice orientation

image quality

The diagnostic quality of an MR image. Characteristics include:

→ artifact

→ image contrast (contrast-to-noise ratio)

→ image noise (signal-to-noise ratio)

→ spatial resolution

image reconstruction

The process of creating images from a set of raw data measured. With MRI, the Fourier transform is used for reconstruction.

image reconstruction system

MR component: The part of the computer system that reconstructs images from the acquired raw data.

image registration

Postprocessing: To register two images means to align them, so that common features overlap and differences between the two, should there be any, are emphasized and readily visible.

image resolution

→ spatial resolution

image subtraction

Postprocessing: In contrast-enhanced studies, image subtraction is a simple post-processing technique that enables digital subtraction of precontrast and postcontrast images without an additional scan. Subtraction images allow for better visualization of the contrast enhancement.

imaging protocol

→ measurement protocol

imaging sequence

→ pulse sequence

inflow technique

→ time-of-flight angiography (TOF)

infolding artifact

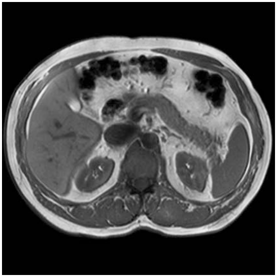
→ overfolding artifact

inline display

Image display: Immediate display of reconstructed images. Frequently used to display dynamic changes (for example, Care Bolus and BOLD imaging).

in-phase image

MR measurement: An in-phase image is generated with a measurement at a time when two components in the tissue (usually fat and water) are in the same phase, that is, the **transverse magnetizations** have the same orientation and add up. The cause for different phase-velocities is the **chemical shift** between fat and water protons.



in-plane resolution

Image quality: In-plane resolution is determined by the size of the **pixels**. The smaller the pixel, the better the in-plane resolution.

interactive real-time imaging

MR measurement: MR-guided interventional procedures, such as biopsies, thermal ablations, and intravascular procedures, require real-time monitoring of the procedure and interactive slice positioning based on the path planning.

Interactive real-time MRI supports such interventional examinations as the user can interactively change the scan plane positions and orientations during data acquisition, that is, in real time. See also **interactive real-time tip tracking**.

interactive real-time tip tracking (IRTTT)

MR measurement technique: Software-based tracking of devices that have receive microcoils embedded (for example, a catheter). The user can attach slices to the microcoil-equipped part of the device and follow its movements. Moreover, slices can be automatically oriented (perpendicular, parallel, three-point plane) according to the detected position and orientation of the device.

interactive shim

Magnetic field: Manual adjustment of the shim coils used to improve magnetic field homogeneity. Shim currents can be set and optimized individually for a selected pulse sequence.

interleaved slices

→ slice sequence

interpolation

MR measurement: Calculation of values that lie between known values; for example, enlarging the image matrix from 256 × 256 to 512 × 512. The measurement time is not increased, but interpolated images require more storage space.

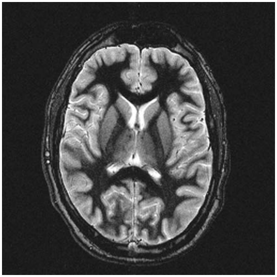
interventional MRI (iMRI)

MRI-guided minimally invasive procedures. Generally, “Interventional” MRI refers to less invasive procedures such as biopsies, thermal ablations, and intravascular stent placements. The acronym iMRI is commonly used to include “Intraoperative” applications, that is, surgical interventions such as craniotomy for tumor resection.

inversion recovery (IR)

MRI measurement technique: Inversion recovery pulse sequences are used to give strong T1 weighting. The basic part of an inversion recovery sequence is a 180° pulse that is applied before the normal pulse sequence in order to null the signal from a specific tissue. The inversion time TI between the inversion pulse and the start of the normal pulse sequence affects what tissue will be nulled.

For example, fat returns back very quickly compared to that of water making it possible to perform **STIR** (fat suppressed) and **FLAIR** (fluid suppressed) imaging by selecting the appropriate null point for the fat and water atoms.



inversion time (TI)

Measurement parameters: Interval between a 180° inversion pulse and a 90° excitation pulse in an inversion recovery sequence.

iPAT

MRI measurement technique: iPAT stands for integrated Parallel Acquisition Techniques. iPAT is Siemens' implementation of Parallel Acquisition Techniques (PAT) on MAGNETOM systems.

iPAT includes the mSENSE and GRAPPA measurement techniques as well as autocalibration and CAIPIRINHA.

iPAT^2

3D imaging: 3D sequences include two phase-encoding directions: the conventional 2D (PE) direction and the additional phase encoding in the partitions direction (3D).

The acceleration in the 3D direction is known as "iPAT^2".

isocenter

Image quality: The main magnetic field is only homogeneous within a roughly spherical region about the isocenter of the magnetic field. In this area, the examination region is positioned to ensure the best possible image quality.

isotope

MR-PET examination:
An important property of atoms is their atomic number (number of protons in the nucleus). An atom's atomic number determines its chemical properties. Similarly, an atom's atomic mass number is defined as the total number of nucleons (protons and neutrons) in the atom.

Isotopes are atoms with identical atomic numbers but different atomic masses. Although isotopes have the same chemical properties as other atoms of their element, they have very different nuclear properties.
For example, although many isotopes are stable, some isotopes have unstable nuclei and are radioactive. The isotopes used in PET scans are all radioactive and decay rapidly.

Commonly used isotopes include:

- carbon-11 or ^{11}C
- nitrogen-13 or ^{13}N
- oxygen-15 or ^{15}O
- fluorine-18 or ^{18}F (see also **fluorodeoxyglucose**)

isotropic MR imaging

MR measurement technique: High-resolution isotropic 3D imaging uses isotropic 3D sequences to allow reformatting of images in any plane depending on the suspected anatomy of interest. A useful method of improving workflow and providing improved through-plane resolution.

iterative denoising

Image reconstruction: Image reconstruction technique that can be applied to improve image quality for low SNR scans. It can be applied to almost all routine 2D and 3D MR acquisitions.

jet effect

Image quality: Spin dephasing for complex flow patterns such as turbulences. The degree of signal loss and the size of low-signal regions depend on the flow patterns and pulse sequence used. This effect must be taken into account when evaluating the extent of vascular stenosis.

k-space

k-space is the 2- or 3-dimensional data model holding the digitized raw data for an image measured. Usually, k-space is identical to the **raw-data matrix**, which is filled line by line by conventional measurement techniques.

The axes of k-space are known as k_x (horizontal axis) and k_y (vertical axis). The data points of the plane spanned by these axes represent **spatial frequencies**. A **Fourier transform** converts these spatial-frequency data into the final image data to be visualized.

k-space trajectory

MR measurement: The path traced in the spatial-frequency domain during k-space sampling as determined by the applied gradients. Common k-space trajectories used in MRI comprise the following methods: Cartesian, radial, spiral, zig-zag, and BLADE.

label map

Neuroimaging: Brain morphometry results are visualized as **deviation maps** and label maps. The label map shows each region of the brain in a different color, using a color-coding scheme.

Larmor frequency

MR physics: **Frequency** at which the nuclear spins precess around the direction of the outer magnetic field (also known as precession frequency). The Larmor frequency depends on the type of nucleus and the strength of the magnetic field.

At 1.0 tesla, the Larmor frequency of protons is approx. 42 MHz; at 1.5 tesla, it is approx. 63 MHz.

→ **precession**

lattice

MR physics: Magnetic and thermal environment where the nuclei exchange energy during **longitudinal relaxation**.

line of response (LOR)

MR-PET examination: The axis of the projection beam. Please note: In PET, it is the line connecting the centers of two opposing detector elements operated in coincidence.

list mode data

MR-PET examination:
List mode data are the raw data of a PET examination. In addition to **sinograms**, list mode data contains exact temporal information on every event, including trigger information. List mode data are converted to sinograms prior to reconstruction.

local AIF method

Perfusion imaging: The local AIF (arterial input function) method determines the incoming flow of contrast agent for a reference volume around every voxel. This method reduces artifacts due to the arterial flow differences between different regions. Unlike the global AIF method, it determines the incoming flow of contrast agent at one reference point for all voxels.

local coil

MR components: Local coils are RF receiver coils for individual parts of the body. Local coils have a high signal-to-noise ratio.

local SAR

Safety: Specific absorption rate (SAR) averaged over any 10 g of tissue of the patient's body and over a specified time.

local shim

Magnetic field: The **shim** is limited to a previously selected local volume.

→ **3D shim**

localized MIP

MR angiography: Localized "MIPing" improves image quality. Only a partial data volume is used which contains the voxels of the vessel of interest. As a result, the projection includes fewer background noise pixels and displays less bright fat signal. Individual vessels can be selected as well for reconstruction used to maintain a comprehensive image.

localizer

Measurement: Image acquired as the basis for **slice positioning**. Synonym: scout.

logical gradient

MR measurement:
For orthogonal slices, each of the 3 **physical gradients** has exactly one "logical" task: **slice selection**, **frequency encoding**, and **phase encoding**. For oblique slices, the logical gradients are a mix of the physical gradients.

longitudinal magnetization (M_z)

MR physics: Longitudinal magnetization M_z is the portion of the macroscopic magnetization vector in the direction of the z-axis, that is, along the outer magnetic field. After excitation by an RF pulse, M_z returns to equilibrium M_0 with a characteristic time constant T1.

$$M_z(t) = M_0\,(1-\exp(-t/T1))$$

longitudinal relaxation

MR physics: Return to equilibrium of the longitudinal magnetization after excitation, due to the energy exchange between the spins and surrounding lattice (also called spin-lattice relaxation).

longitudinal relaxation time

→ **T1 constant (longitudinal relaxation time)**

LOTA technique

MRI measurement technique: Data averaging used to reduce motion artifacts. During measurement, a complete raw data set is measured for each data acquisition. At the end of the measurement, several complete raw data sets are available and averaged.

low-field MRI

MR technology: MR systems and devices with several magnitude lower field strength (typically well under 0.1T) than most stationary units.

magnet

A magnet is a material or object that produces a magnetic field. For details about specific types of magnets see:

→ permanent magnet

→ resistive magnet

→ superconductive magnet

magnet bore

MR components: The magnet bore is the opening in the main magnet where the patient is placed for examination.

magnet ramp time

Magnet technology: Time required for the magnetic field strength to change, measured in T/min. Depends on the construction of the magnet and the design of the magnet power supply.

magnetic field

MR physics: The space surrounding a magnet (or a conductor with current flowing through it) has special characteristics. Every magnetic field exercises a force on magnetizable parts aligned along a primary axis (magnetic north or south pole). The effect and direction of this force is symbolized by magnetic field lines.

magnetic field gradient

→ gradient system

→ stray field

magnetic field homogeneity

→ homogeneity

magnetic field strength

MR physics: The strength of the magnetic field force on magnetizable parts. In physics, the effect is called magnetic induction. In MR, it is referred to as magnetic field strength. Units: tesla (T), 1 tesla is approximately 20 000 times the strength of the earth's magnetic field.

magnetic resonance (MR)

MR physics: Absorption or emission of electromagnetic energy by atomic nuclei in a static magnetic field, after excitation by electromagnetic RF radiation at resonance frequency.

magnetic resonance elastography (MRE)

→ MR elastography (MRE)

magnetic resonance fingerprinting (MRF)

→ MR fingerprinting (MRF)

magnetic resonance imaging (MRI)

Images of objects, for example, the human body, are displayed with magnetic resonance using magnetic gradient fields. In practical application, the distribution of protons in the body is displayed.

The clinically relevant objective of MR imaging is the differentiation between pathological and healthy tissue (image contrast).

magnetic shielding

In space: Active shielding (AS)

Through tissue: Weakening of the applied magnetic field at the nucleus by the counter field induced in the electron shell of the surrounding tissue.

→ chemical shift

magnetizability

→ susceptibility (magnetizability)

magnetization

MR physics: Magnetization is a quantity measuring the magnetic force a material can exert on its environment.
In MRI, the macroscopic magnetic net effect of spin ensembles is measured. This net magnetization of tissue voxels of interest determines the potential strength of the MR signal.

magnetization preparation

MRI measurement technique: Technique to improve or modify the image contrast. Additional RF pulses (magnetization preparation pulses) are used to preset the net magnetization to a given state prior to the execution of the spatial localization. Example of a magnetization-prepared (MP) sequence: MPRAGE.

magnetization transfer contrast (MTC)

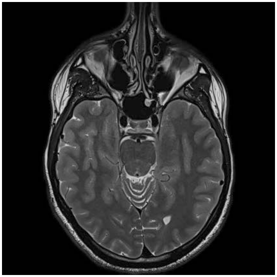
MRI measurement technique: Indirect observation of fast relaxing magnetization through presaturation. Through magnetization transfer contrast, the signal from specific “solid” tissue (for example: brain parenchyma) is reduced, and the signal from a more fluid component (for example: blood) is retained.

With MTC, the saturation of bound protons is transferred to adjacent free protons. This reduces the visible MR signal in these areas.

magnitude image

Image reconstruction: Normal image display. In a magnitude image, the gray value of a pixel corresponds to the magnitude of the MR signal at that location.

Alternative: phase image



magnitude image

MR elastography: Image obtained with an MR elastography sequence, which shows signal loss and blurring due to the effects of the applied magnitude encoding gradients. Useful for identifying the anatomic location of the elastogram.

matrix

→ image matrix

→ raw-data matrix

matrix size

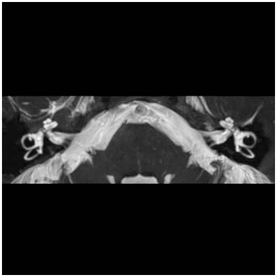
Measurement parameters: Size of the raw-data matrix; influences not only the spatial resolution, but also the measurement time and signal-to-noise ratio.

With a square raw-data matrix, the number of rows equals the number of columns.

maximum intensity projection (MIP)

Postprocessing: Maximum intensity projection is a volume rendering technique for 3D images that projects in the visualization plane the voxels with maximum intensity that fall in the way of parallel rays traced from the viewpoint to the plane of projection. At each pixel the highest data value encountered along the corresponding viewing ray is determined.

MIP exploits the fact, that within MRI data sets the intensity values of vascular structures are higher than the intensity values of the surrounding tissue. By depicting the maximum intensity value seen through each pixel, the structure of the vessels contained in the image can be captured.



MDDW

Diffusion imaging: To compute the **diffusion tensor**, the technique provides multidirectional diffusion weighting (MDDW) measurements in at least 6 spatial directions. One diffusion-weighted image each is generated per **slice position**, **b-value**, and direction of diffusion (for b > 0).

measurement field

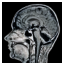
Image quality: Spherical volume in the center of the magnetic field where the field has a defined homogeneity. For MRI examinations, objects to be measured have to be positioned at all times in the measurement field (to prevent signal distortions).

measurement matrix

Raw-data matrix, not to be confused with the **image matrix**.

measurement program

MR measurement: The sequences and parameter settings as well as the typical workflow of frequently performed examinations.



measurement protocol

MRI measurement technique:
A measurement protocol is a **pulse sequence** with a full set of optimized parameters chosen for performing a specific type of examination.

measurement sequence

→ **pulse sequence**

measurement time

MR measurement:
The measurement time for a 2D measurement is as follows:

Measurement time =
no. of scans (**phase-encoding steps**) × **repetition time (TR)** × no. of **acquisitions** (NA)

MEDIC

MRI measurement technique:
Multiple echoes acquired in one measurement are combined into an image.
The advantage: higher receiver bandwidth, fewer artifacts.
Application: cervical spine, joints.

millitesla per meter (mT/m)

Gradient technology:
Measurement unit for the **gradient strength**.

minimum intensity projection (MinIP)

Postprocessing: Volume rendering technique. Similar to **maximum intensity projection (MIP)**, but used to display low density objects.

MIP

→ **maximum intensity projection (MIP)**

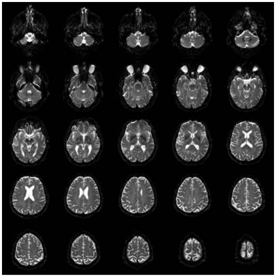
modality performed procedure step (MPPS)

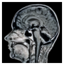
DICOM service: The modality performed procedure step service, commonly known as MPPS, provides a mechanism for image modalities to pass information about the imaging they are performing back to the RIS and/or PACS.

For example, information of images acquired, duration of the study, beginning time and end time of the examination, etc.

mosaic image

BOLD imaging: The whole volume, between 16 to 64 EPI images, are compiled into a mosaic image. This increases the clarity of BOLD displays.





motion artifact

Image quality: Results from random or involuntary movement: breathing, heartbeat, blood flow, eye movement, swallowing, and patient movement. The effect appears as **ghost images** or **smearing artifacts** in the images. In the phase-encoding direction only.

motion correction

Image quality: Motion correction is a class of procedures for eliminating motion artifacts during measurement (prospective) or after measurement (retrospective).

→ **syngo BLADE**

→ **syngo BRACE**

→ **PACE**

movie mode

Image display: To display dynamic processes such as cardiac movement. The MR images run automatically through the active screen segment, either in a cycle or forward and backward (yoyo).

MPR

→ **multiplanar reconstruction (MPR)**

MPRAGE

MRI measurement technique: MPRAGE is a 3D extension of the TurboFLASH technique with inversion preparation pulses. Only one segment or partition of a 3D data record is obtained per preparation pulse.

MR angiography (MRA)

MR application: Depiction of vessels with MR. However, MRA does *not* really display the blood volume, but rather a specific physical characteristic of the blood; for example, the magnetization status or local velocity. This is perceived as blood volume. MRA does *not* display a single vessel, but rather all vessels in the measured volume. Various views can be subsequently reconstructed (**MIP**) from 3D data volumes.

MR breast biopsy

MR application: Application for planning access to the lesion when performing a breast biopsy. Based on the positions of the marker and lesion defined in the breast images, the software calculates the settings for the positioning unit and needle guide.

MR cardiology

MR application: The advantages of cardiac MR include:

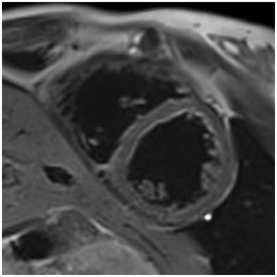
- free selection of image planes and FOVs
- high tissue contrast
- temporal and spatial resolution

Multiple cardiac slices can be acquired along the respective slice plane. In this way, complete anatomical display of the heart in all three dimensions is provided.

Data records acquired across cardiac phases enable **movie display** of the heartbeat.

Subsequent quantitative evaluation of cardiac studies enables, for example, the following:

- Calculation of ventricular volume, myocardial mass, and functional parameters
- Manual or semi-automatic segmentation of the inner and outer cardiac walls of the left ventricle, and the inner wall of the right ventricle: ED and ES images or the complete cardiac cycle.
- Evaluation of myocardial wall thickness; changes in wall thickness (between the ED and ES phase or during the cardiac cycle) are evaluated for each sector



MR contrast agent

→ contrast agent

MR elastography (MRE)

MR application: Imaging of propagating mechanical waves using MRI. MRE uses low-frequency mechanical waves to probe the elastic properties of tissue, providing a non-invasive way of measuring the stiffness of biological tissue. The technology requires modest software and hardware upgrades to a conventional MR scanner.

MR fingerprinting (MRF)

MR application: MR fingerprinting is not an imaging technique, instead it creates a complex signal response from the tissue and derives parametric maps directly from the data. MRF uses measurements and quantification to identify tissue and morphological changes for enhanced therapy precision and treatment evaluation, based on absolute data.

Acquisition parameters are varied in a pseudorandom fashion, and the resulting unique signal patterns are recorded as fingerprints of tissues. A fingerprint is the intensity variation of a voxel across the images, i.e., along the time points. After the acquisition, a pattern recognition algorithm is used to find the dictionary entry that best represents the acquired signal evolution of each voxel. Each MR fingerprint points to the MR related identification features of the associated tissue (such as T1, T2, relative spin density, B0, diffusion, etc.). See also **MRF dictionary**.

MR image

The MR image consists of a multitude of image elements, also known as **pixels**. Pixels are allocated to a matrix in a checkered pattern. Every pixel in the image matrix displays a specific gray scale. Viewed as a whole, this gray scale matrix provides the image.

The gray scale of a pixel mirrors the measured signal intensity of the corresponding volume element (**voxel**). In turn, the signal intensity of a voxel depends on the respective transverse magnetization.

MR imaging

→ **magnetic resonance imaging (MRI)**

MRF dictionary

MR fingerprinting: In MR fingerprinting, recorded fingerprints of tissue are matched against an existing dictionary, a database containing hundreds of thousands of precomputed fingerprints. Each fingerprint in the dictionary points to MR-related identification features of the associated tissue (such as T1, T2, relative spin density, B0 inhomogeneity, diffusion, etc.). See also **MR fingerprinting**

MR-PET examination

Process of acquiring data using a dual-modality imaging system MR plus PET scanner.

MR sensitivity

MR physics: Atomic nuclei for MR examinations have to be "MR sensitive"; that is, they must have a nuclear spin. This condition excludes all atomic nuclei with an even number of protons and neutrons.

Since the hydrogen isotope ^{1}H is the most sensitive, it is used as a reference in relationship to other atom nuclei. Its relative sensitivity is 1 or 100 %.

MR sequence

→ pulse sequence

MR signal

MR physics: Electromagnetic signal in the RF range. Caused by the precession of transverse magnetization created by a variable voltage in a receiver coil (dynamo principle).
The temporal progression of this voltage is the MR signal. Different MR signals in different tissue voxels generate the image contrast.

MR spectroscopic imaging (MRSI)

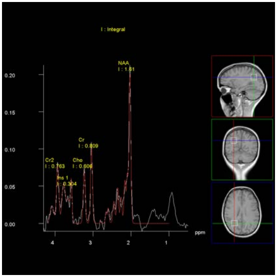
→ MR spectroscopy (MRS)

MR spectroscopy (MRS)

MR application: MR spectroscopy provides the noninvasive measurement of cellular metabolic relationships.
An MR spectrum shows the dependence of the signal intensity on the chemical shift for a measurement volume (voxel). The concentration of metabolites contributing to the spectrum can then be inferred.

In MR spectroscopy, the MR signal is measured as a function of time: a rapidly decreasing high-frequency oscillation. Using a Fourier transform, the oscillation is converted into a display of its frequency components, the **spectrum**.

In the area of intermediary metabolism, MR spectroscopy is an important method for in-vitro and in-vivo examination of tissue and organs.



mSENSE

MRI measurement technique: Further development of **SENSE** with **autocalibration** and a modified algorithm for image reconstruction.

mu map

MR-PET examination:
In order to obtain quantitative PET information, MR-PET imaging relies on MR information that is processed into an MR-derived attenuation map (mu map), which in turn can be used for **attenuation correction** of PET data.

multibed/multistep examination

MR-PET examination:
A whole-body MR-PET examination acquires data in sections, which are called beds or steps. MR-PET examinations that cover large examination regions are divided into several beds and multiple steps.

multidirectional diffusion weighting

→ **MDDW**

multi-echo Dixon

MR measurement technique:
Evaluation method for calculating hepatic proton density fat fraction (PDFF).

multiecho sequence

MRI measurement technique:
Pulse sequence that acquires multiple echoes with different degrees of T2 weighting. Signal height reduces with transverse relaxation. This drop in signal can be used to calculate a pure T2 image.

multinuclear imaging

MR application: Primarily a research technique for imaging other nuclear spins than hydrogen protons, such as sodium and phosphorus.

Alternative **contrast agents** such as hyperpolarized helium can be used as well.

Potential applications are imaging of low-contrast structures such as lungs and bones and **functional imaging**. The Siemens Multinuclear Option allows transmit and receive experiments with the nuclei ^{3}He, ^{7}Li, ^{13}C, ^{19}F, ^{23}Na, ^{31}P, and ^{129}Xe.

multinuclear spectroscopy (MNS)

MR spectroscopy: Spectroscopic investigations using other nuclear spins besides hydrogen protons, such as carbon and phosphorus. Used to study metabolism and intracellular pH levels, particularly of the liver.

multiparametric MRI (mpMRI)

MR application: Any functional form of imaging used to supplement standard anatomical T1 and T2-weighted imaging. The functional sequences can be dynamic contrast-enhanced (DCE) MRI, diffusion-weighted imaging (DWI), including the calculation of apparent diffusion coefficient (ADC) maps, MR spectroscopy, or any other functional sequence.

multiplanar reconstruction (MPR)

Postprocessing: Enables the calculation of images of any orientation to be reconstructed based on a 3D or gapless multislice measurement.

multiregion examination

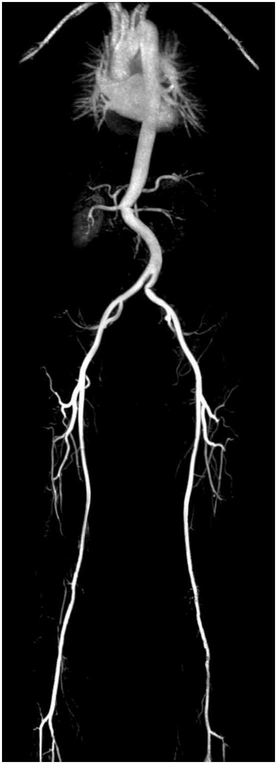
MR measurement: A multiregion examination examines more than one part of the body in a single examination workflow. For example, a multiregion examination might cover the head, the neck, and the upper part of the spine.

multislice imaging

MRI measurement technique: Variant of sequential imaging. The recovery period of the first slice excited is used to measure additional slices (time-savings). The slices are **interleaved**.

multistation MRA

MR angiography:
For peripheral or whole-body angiography, multistation MRA allows the measurement of large areas extending the FOV of the MR system.
The area to be examined is measured at individual sections (stations), during automatic table feed. The data obtained are subsequently combined into an overall image.



multistep angio

→ multistation MRA

multivenc sequence

Phase-contrast angiography:
A sequence that is equally sensitive to various flow velocities. Used to acquire wide variations in flow velocity, for example, in the peripheral arteries.

myExam add-in

MR measurement: myExam add-ins are auxiliary software components for myExam Assist programs. As a kind of plug-in to a program step, they enhance it with specific features. See also myExam Assist.

myExam Assist

MR measurement: myExam Assist programs provide an optimized MRI workflow with a customizable framework for patient personalization, step-by-step user guidance, and an automated examination. myExam Assist programs are available for various applications, for example, myExam Brain Assist, myExam Cardiac Assist, myExam Angio Assist.

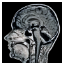
myExam Assist programs can comprise **AutoAlign** for automatic slice positioning.

myExam Autopilot

MR measurement: Automated scanner software that allows less skilled radiology technologists to perform reproducible, standardized MRI exams. The software supports multiple exam strategies and protocols do not need to be manually adjusted. myExam Autopilot is available for several body regions, for example myExam Brain Autopilot, myExam Spine Autopilot, and myExam Knee Autopilot.

myExam Cockpit

MR measurement: Task-oriented central user interface for all protocol management tasks. This includes flexible configuration of all myExam Assist programs and non-myExam Assist protocols.



myExam Companion

MR measurement: New philosophy to operate MRI providing built-in expertise and automation for any user and clinical question. myExam Companion provides different scan modes for tailored assistance: **myExam Autopilot**, **myExam Assist**, and **myExam Cockpit**. Patient preparation and registration can be more efficiently and consistently performed with myExam 3D Camera. With its capabilities to help users generate consistent, comprehensive results, myExam Companion is an advancement of Healthineers Dot Technology.

myExam decision

MR measurement: Element of **myExam Assist**. Decisions build the structure of an examination by offering different paths. Typical decision points are “Contrast agent” yes/no, or “Diffusion” yes/no.

myExam strategy

MR measurement: For myExam Assist programs, several parallel program paths for a dedicated examination can be configured. These paths are called strategies. A strategy is a set of predefined steps, which together create a program for a specific patient situation. Prior to and during an examination, the measurement strategy can be changed according to the needs of the measurement and patient behavior.

For example, if the patient is not cooperative, you can select a suitable strategy such as motion-insensitive BLADE.

myocardial mapping

Cardiac imaging: Technique to generate pixel-based parametric maps for myocardial relaxation times (T1 map, T2 map, and T2* map).

myocardial nulling

Cardiac imaging: Inversion recovery pulse sequence that is used to null the signal from a desired tissue to accentuate surrounding pathology.

myocardial tagging

Cardiac imaging: A noninvasive technique for imposing grids or stripes on myocardial images, useful for assessing intramyocardial motion and deformation. The noninvasive tags are created within the tissue by local modulations of the magnetization which produce regions of reduced signal intensity.

The standard tagging method for producing grids is known as complementary spatial modulation of magnetization (CSPAMM).

→ grid tagging

→ stripe tagging

native image

Contrast-enhanced examination: MR image without the use of contrast agent, for example, as a precontrast study.

navigator sequence

MRI measurement technique: Additional spin or gradient echoes for detecting changes in object position in a measurement volume, or other changes. Suitable for use with interventional procedures or **respiratory gating**.

NEMA

The Assocation of Electrical Equipment and Medical Imaging Manufacturers in the United States. The Medical Imaging & Technology Alliance (MITA), which is a division of NEMA, represents manufacturers of medical diagnostic imaging equipment including MRI, CT, x-ray, and ultrasound products.

neuroimaging

MR application: General term for brain and nervous-system applications, such as **BOLD imaging**.

nonselective pulse

MRI measurement technique: When data are acquired with a nonselective pulse, a longer TR is required for multislice measurements or repeated measurements of the same slice. The longer TR is required to ensure that magnetization between consecutive measurement recovers sufficiently and that the individual measurements do not interfere with one another.

Use with 3D volume measurements and presaturation techniques (for example: **magnetization transfer contrast**).

normalization filter

Image quality: Equalizes signal intensity when using surface coils. Using the filter, the signal intensity of areas close to the coil is reduced; the signal intensity is increased in areas farther from the coil.

Used primarily with **array coils**.

nuclear Overhauser effect (NOE)

MR spectroscopy: Nuclear magnetic resonance (NMR) phenomenon in which the irradiation of one nuclear spin species (e.g. 1H) with an RF field causes an increased or decreased magnetization of another spin system (e.g. 31P) which is observed as an increased or decreased resonance (peak).

nuclear spin

MR physics: Atomic nuclei with an odd number of neutrons and protons have what is called nuclear spin. For MR imaging, mainly hydrogen protons are used. For MR spectroscopy, other nuclei are used as well, such as phosphorus, fluorine, and carbon.

number of acquisitions (NA)

→ average

number of partitions

→ partition

number of slices

Measurement parameters: Multiple slices are usually acquired during an MR measurement. The maximum number of slices of a pulse sequence or measurement protocol depends on the repetition time TR.

→ multislice imaging

oblique slice

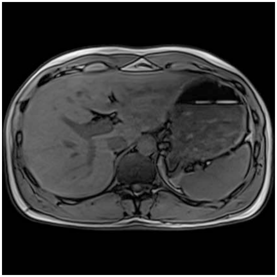
Measurement parameters: Obtained by rotating an orthogonal slice (sagittal, coronal, or transverse) about a coordinate axis in the image plane.

off-center

Slice positioning: Shifting the center of a slice group from the center of the magnetic field within the slice plane.

opposed-phase image

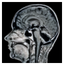
MR measurement:
An opposed-phase image is acquired at a time when two components in the tissue (usually fat and water) have opposite phases, that is, the transverse magnetizations of the two components have opposite orientations and partially cancel one another. Cause for the difference in phase is a chemical shift between fat and water protons.



orthogonal slice

Slice positioning: Slices oriented perpendicular to one another. Three basic orientations are available: sagittal, coronal, and transverse (axial)

→ slice orientation



outer volume suppression (OVS)

MR measurement technique: Sequence that utilizes one or more spatially selective pulses applied in the OV regions followed by dephasing gradients. The OVS sequence is placed before the slice excitation pulse of the imaging sequence. Effective OVS requires complete dephasing of the transverse magnetization and nulling of all longitudinal magnetization at the time of the excitation pulse.

out-of-phase image

MR measurement: An out-of-phase image is generated with a measurement at a time when two components in the tissue (usually fat and water) are not in the same phase.

overfolding artifact

→ **aliasing artifact**

oversampling

Measurement parameters: Method for preventing **aliasing artifacts**.

Readout oversampling: Doubling the sampling points in the **frequency-encoding** direction without prolonging the measurement time. The additional part is discarded after reconstruction.

Phase oversampling

Measurement data acquisition beyond the **FOV** in the **phase-encoding** direction. Increases the SNR. The measurement time increases accordingly. 100 % phase oversampling has the same effect as double the number of acquisitions.

PACE

Image quality: During the measurement, PACE corrects respiratory and motion artifacts in real time by reducing the offset between the slices. This allows for multiple breath-hold examinations a well as free breathing during a measurement, for example.

→ 1D PACE

→ 2D PACE

paradigm

BOLD imaging: Planned sequence of the functional measurement, for example: 10 nonactivated images (baseline), 10 active images.

parallel acquisition techniques

→ PAT

parallel imaging

→ PAT

parallel saturation

Slice positioning: By saturating areas parallel to the slice plane but outside the slice stack, blood flowing to the measurement area produces almost no signal at the beginning of the measurement. This eliminates the vascular intraluminal signal, and prevents **ghost images** in the phase-encoding direction.

This **presaturation** can be performed on both sides of the slice. Parallel saturation slices shift with the slices of interest, simplifying planning.

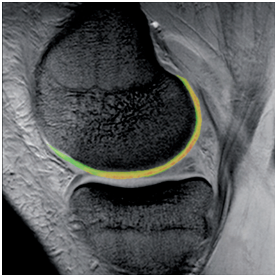
parallel transmission (pTx)

MRI measurement technique: Parallel transmission describes the use of multiple RF transmit coils.

parameter map

Postprocessing: A parameter map is a graphical representation of functional information, generated by a postprocessing protocol from the measured data.

Parameter maps display the T1, T2, or T2* characteristics of the acquired tissue, enabling early detection of arthritis, for example.



Diffusion imaging: Parameter maps in diffusion imaging can be created by measuring the **diffusion tensor**. They may be used to display, for example, anisotropic diffusion characteristics of the brain(example: **FA map**). See also **ADC map**.

Perfusion imaging: To display interferences in perfusion (example: **time-to-peak map (TTP)**).

partial-body SAR

Safety: Specific absorption rate (SAR) averaged over the mass of the patient's body that is exposed to the volume RF transmit coil and over a specified time.

partial Fourier

MRI measurement technique: To reduce the phase-encoding steps during the measurement so that the raw-data matrix is filled with fewer rows. Allows for shorter echo times. Special case: **half-Fourier matrix**

partial parallel acquisition (PPA)

→ **PAT**

partition

3D imaging: During 3D imaging, entire volumes and not just individual slices are excited. A **3D slab** comprises multiple gapless partitions. The number of partitions corresponds to the number of slices during 2D imaging.

partition thickness

3D imaging: The effective slice thickness of individual partitions in a **3D slab** is the slab thickness divided by the number of partitions.

parts per million (ppm)

Dimensionless unit comparable to percent. While percent means out of one hundred, ppm means out of one million. Used to measure **chemical shift** in MR spectroscopy examinations. Deviations of the main magnet field B_0 from the normal value are also stated in ppm.

PAT

MRI measurement technique: PAT is the generic term for parallel imaging techniques. Other terms for PAT include “Parallel Imaging” and “Partial Parallel Acquisition”.

Two groups of PAT are differentiated: with the image-based methods (for example: **SENSE**, **mSENSE**), the PAT reconstruction is performed following the **Fourier transform**.

With the k-space-based methods (for example: **SMASH**, **GRAPPA**), the PAT reconstruction is performed prior to the **Fourier transform**.

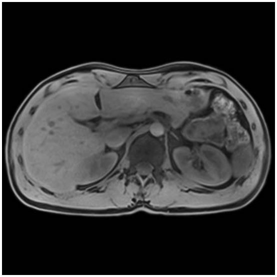
PAT shortens the **measurement time** without degrading **image resolution**. The lower number of measurement lines reduces the **signal-to-noise**.

A prerequisite for PAT is the use of **array coils** as well as the calculation of the **coil profile** of all array coil elements (for example: via **autocalibration**).

The most important advantages of PAT: shorter breath-hold times, higher temporal resolution of dynamic measurements and sharper images with **echo-planar imaging** (by reducing the **echo train**).

→ iPAT

→ iPAT2



PAT factor

Measurement parameters: The PAT factor is a measure of the phase-encoding steps reduced through PAT. Example: for a PAT factor of 2, every other step is skipped. This cuts the measurement time in half.

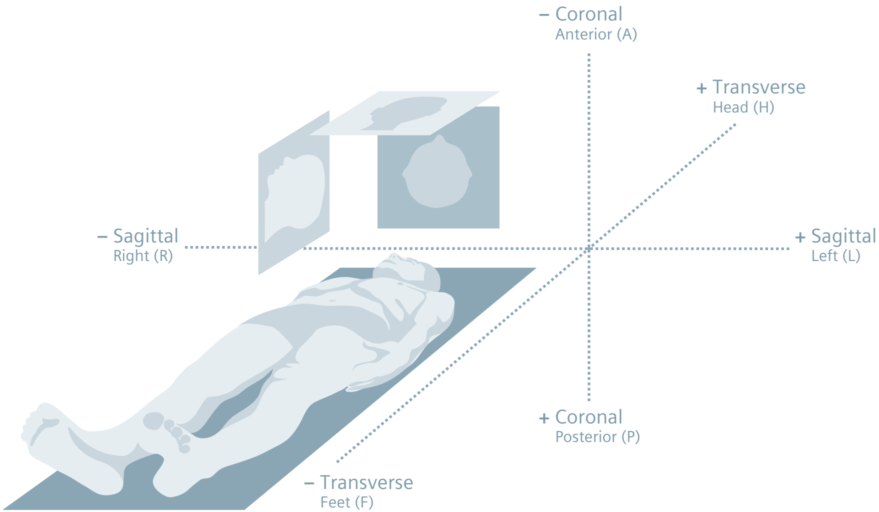
For iPAT², the PAT factor is the product of the two PAT factors in the phase-encoding and the partitions direction. Example: a PAT factor of 4 in the phase-encoding direction and a PAT factor of 3 in the partitions direction results in a total PAT factor of 12.

patient coordinate system

In *syngo* MR clinical images, the orientation is stated by a patient-related coordinate system.

This system indicates the direction from which a user is looking at the patient and how a slice is positioned.

Coordinate axes are feet to head, right to left, and anterior to posterior.



patient registration

Measurement preparation: Prior to an MR examination, the patient has to be registered. The patient data are entered, providing for a clear allocation between the patient and the MR image.

PBP map

Perfusion imaging: A percentage of baseline at peak map can be reconstructed for the slice. The gray scale displays the signal change relative to a baseline image prior to administering contrast agent.

PC Angio

→ **phase-contrast angiography (PCA)**

peak

MR spectroscopy: Theoretically, the frequency display of a pure sine wave is a single spectral line at the point of the **resonance frequency**. In reality, the spectral line spreads into a blurred peak. The cause are the spin-spin effects and the field inhomogeneity (magnet and patient).

Peak characteristics: resonance frequency (ν_0), peak height (*h*), peak width at half height (*b*) (full width half maximum FWHM), area.

percentage of baseline at peak

→ PBP map

perfusion imaging

MR application: Perfusion is one of the most important physiologic and pathophysiologic parameters and can be assessed non-invasively with MRI. There are several techniques to derive perfusion-related parameters using endogenous contrast methods (for example, arterial spin labeling), or exogenous contrast agent dynamic methods.

perfusion-weighted image

Perfusion imaging: Perfusion-weighted images visualize the diagnostically relevant parameters of tissue perfusion.

peripheral angiography

MR application: MR angiography of the peripheral vascular system; has special requirements:

- arterial flow is often pulsating
- large volumes have to be measured
- images must clearly distinguish between arteries and veins

Most often, 3D gradient-echo protocols with or without contrast agent (NATIVE, QISS) are being used. Measurements are performed with tabletop movement in several stations. They require an optimized timing sequence.

peripheral nerve stimulation (PNS)

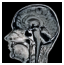
MR safety: Effect on the human body caused by time-varying magnetic fields. If the electrical fields generated exceed a specific threshold, electrical currents can be induced in the patient's body and stimulate nerves or muscles. This stimulation may be considered uncomfortable for the patient and is an important value for establishing safety limits.

permanent magnet

MR components: Permanent magnets consist of large blocks of magnetic material, usually horseshoe-shaped. They have a permanent magnetic field. As a result, they do not need to be supplied with energy or cooling.

PETRA sequence

MRI measurement technique: Sequence for 3D T1 imaging, requiring very limited gradient activity. Part of the **Quiet Suite** for reducing noise levels during MR examinations.



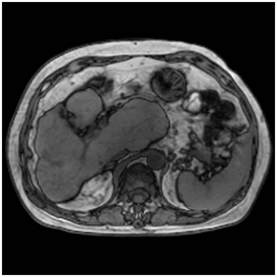
phantom

Quality assurance: Synthetic item with known dimensions and measurement characteristics. Usually a container filled with fluid and a built-in plastic structure of various sizes and shapes. Phantoms are used to test the system and the quality features of imaging systems.

phase cancellation (chemical shift)

Image quality: Fat and water protons have only slightly different **resonance frequencies**. This results in phase cycling. After an excitation pulse, the fat and water spins of a 1.5 tesla magnet are alternatively in and out of phase every 4.5 ms. For this reason, the signal intensity of a voxel containing fat and water oscillates with an increasing echo time.

The strength of the oscillation depends on the relative proportion of fat and water protons in the tissue.
This effect occurs only with gradient-echo sequences.



phase-contrast angiography (PCA)

MR application: Method for displaying vascular flow.
With PCA, the phase change of the spins in flowing blood induced by velocity is used to distinguish the blood from stationary tissue. Only flowing spins contribute to the signal. The blood contrast in the image is proportional to the local flow velocity.

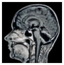
2D and 3D PCA protocols have established flow sensitivity for all three spatial directions. This allows the display of various flow velocities.

Applications: slow flow, “bent” vessels with variable flow direction, overview projection images.

This technique is also the basis for flow measurements.

phased array coil

MR components: A phased array coil is used for parallel imaging. It consists of multiple channels, where each channel has its own receiver. With multiple channels, a scan can be performed many times faster. Phased array coils allow faster image acquisition and therefore greater patient comfort. Moreover, multiple channel technology increases signal and therefore scan quality.



phase difference image

MR elastography: The image generated by subtracting the phase values from images acquired with a positive and negative motion-encoding gradient. The images are acquired synchronously to the phase of the applied waves and (thus) show the propagation of the waves in the displayed tissue.

phase encoding

MR measurement: Method for defining the rows in the **measurement matrix**. Between the RF excitation pulse and the MR readout signal, a magnetic field gradient is switched briefly, applying a phase shift to the spins from line to line. **phase-encoding steps** are required to fully scan the slice depending on the matrix (for example, 256 or 512). The subsequent Fourier transform allocates the various phasings to the respective lines.

phase-encoding gradient

MR measurement: Magnetic field gradient switched in the **phase-encoding** direction.

phase-encoding step

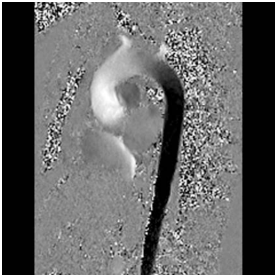
MR measurement: Phase encoding of an MR image normally requires that there are as many excitations and signal acquisitions as there are image matrix rows (for example, 256 or 512).

The amplitude of the phase-encoding gradient changes incrementally from excitation to excitation. For this reason, each row of raw data has different phase information.

phase image

Image reconstruction: In addition to regular **magnitude images**, phase images can also be reconstructed from the raw data measured.

In a magnitude image, the gray scale of a pixel corresponds to the magnitude of the MR signal at that location. In the phase image, each pixel gray scale represents the respective phase between –180° and +180°.



Spin ensembles can be distinguished from stationary tissue in phase images. Stationary spins have the same phase, moving spins have differing phases depending on their velocity.

phase oversampling

→ oversampling

physical gradient

→ gradient coil

physiological measurement unit

→ PMU

phase shift

MR physics: Loss of phase coherence in precessing spins (signal reduction). In most physiological situations, vascular spins move at variable velocities. Faster flowing spins are subject to a stronger phase shift than slower flowing spins.

physiologically controlled imaging

MRI measurement technique: Physiological movements such as the heartbeat, breathing, blood flow, or fluids generally cause artifacts that make an accurate interpretation of an MR image difficult, if not impossible. Physiologically controlled imaging suppresses these artifacts.

→ **cardiac triggering (ECG triggering, pulse triggering), respiratory triggering, respiratory gating**

pixel

Image quality: Smallest picture element of a digital image.
To display the MR image, every pixel in the image matrix contains a specific gray value.

Pixel size = FOV / matrix size

pixel intensity

Image quality: The gray value assigned to pixels in the image data, depending on tissue and measurement parameters.

PMU

MR components: Device for physiologically controlled imaging, which acquires a patient's physiological signals (ECG, respiration and pulse).
The PMU consists of the following components:

- PERU (physiological ECG and respiratory unit),
- PPU (peripheral pulse unit),
- external trigger input.

The physiological signals are acquired with receptors, for example, ECG electrodes, respiratory cushion, and pulse sensor.

positron emission tomograph (PET)

MR-PET examination: Tomographic device, which detects the annihilation radiation of positron-emitting radionuclides by coincidence detection.

postcontrast image

Contrast-enhanced examination: In a contrast-enhanced examination, the postcontrast images are the images measured after injection of contrast agent.

postprocessing

Image evaluation: MR images can be manipulated in various ways for evaluation, for example, **image subtraction**, averaging, rotation, inversion, **multiplanar reconstruction (MPR)**, **maximum intensity projection (MIP)**, etc.

precession

MR physics: Gyration of the rotation axis of a spinning body around another line intersecting it so as to describe a cone.

precession frequency

→ **Larmor frequency**

precontrast image

Contrast-enhanced examination: In a contrast-enhanced examination, the precontrast images are the images measured before the injection of contrast agent, that is, native images.

presaturation

Image quality: Regional presaturation, presaturation with inversion pulses (for example: **dark blood** techniques).

Regional presaturation can be used to reduce the signal from unwanted tissue. For example, to minimize artifacts caused by movement of the thorax.

An additional saturation pulse is applied at the beginning of the pulse sequence to saturate the spins within the saturation slice. The saturated region produces almost no signal and appears black in the image.

PRESS technique

MR spectroscopy: Multiecho single-shot technique to obtain spectral data. The PRESS sequence uses 90°–180°–180° slice-selective pulses.

The long echo times used in PRESS allow a better visualization of metabolites with longer relaxation times.
PRESS is less susceptible to motion, diffusion, and quantum effects and has a better SNR than the stimulated echo acquisition method (STEAM).

projection onto convex sets (POCS)

Measurement parameters: Mathematical procedure for reconstructing images from raw data. This parameter improves the edge sharpness for partial Fourier sampling. Missing k-space data points are not set to zero but are extrapolated.

prospective triggering

Physiologically controlled imaging: Prospective triggering is used to position the data acquisition window into a specific cardiac phase.

protocol

→ measurement protocol

proton density

MR physics: Number of hydrogen protons per unit of volume (generally: spin density).

proton density weighting

Image quality: In a proton density-weighted MR image, contrast is affected primarily by the proton density of the tissue to be displayed. T1 and T2 effects are suppressed.

Pseudo Continuous Arterial Spin Labeling (PCASL)

Perfusion imaging: Technique for blood labeling that uses a train of short low flip angle pulses. All pulses are played out in a narrow labeling slice beneath the imaging volume.

PSIF sequence

MRI measurement technique: The PSIF sequence is a time-inverted **FISP** sequence. It produces a strong T2-weighted contrast in a short measurement time.

pulsed ASL

Perfusion imaging: Pulsed ASL is an **arterial spin labeling** technique which has the advantage of not requiring a contrast agent such as gadolinium-based agents.

pulse sequence

MR measurement: Chronological order of RF pulses and gradient pulses used to excite the volume to be measured, generate the signal, and provide **spatial encoding**.

Typical pulse sequences: spin echo, gradient echo, TSE, Inversion Recovery, EPI, etc.

pulse triggering

Physiologically controlled imaging: Pulse triggering suppresses motion and flow artifacts, as a result of pulsating blood and fluid. The pulse wave obtained with a finger sensor, for example, is used as the trigger.

Although pulse sensors are easier to apply than ECG electrodes, they are less accurate and *not* suitable for cardiac imaging.

QISS

MR angiography: Quiescent interval single-shot (QISS) imaging is a non-contrast MRA technique for peripheral MRA.

- ECG-triggered, single-shot 2D acquisition of one slice per heartbeat.
- In-plane saturation to suppress background tissue and a tracking saturation pulse to suppress venous signal prior to a quiescent inflow period.
- ECG triggering ensures that the quiescent inflow period coincides with rapid systolic flow to maximize inflow of unsaturated spins into the imaging slice.
- Images are acquired with a series of imaging stations around the magnet isocenter. The stations use a series of breath-hold concatenations to minimize respiratory motion.

quality assurance

Method for adjusting the components and parameters of an MR system, for determining **spatial resolution**, contrast resolution, **signal-to-noise ratio**, and other quality-relevant parameters.

quantitative MRI

MR application: Measurement of the MR properties of tissue (proton density, T1 and T2) to characterize biological tissue in order to differentiate different tissues on the basis of these parameters.

quench

Super-conductive magnet: Rapid expulsion of liquid cryogen used to maintain the MR magnet in superconducting state.

Quiet Suite

MR application: The main source of MRI acoustic noise is the rapid switching of the gradient coils, which generates significant mechanical vibrations.

Quiet Suite includes QuietX and PETRA for reducing noise levels during MR examinations and provides optimized protocols for neurological and orthopedic examinations.

QuietX

MRI measurement technique: Algorithm of Quiet Suite for reducing noise levels during MR examinations. Optimizes the gradient trajectory for noise reduction through summation of gradients and reduction of the slew rate, while maintaining image quality and measurement times.

QUIPSS II

Perfusion imaging: Pulsed arterial spin labeling (ASL) technique for improving the quantification of perfusion imaging by minimizing two major systematic errors: the variable transit delay from the distal edge of the tagged region to the imaging slices, and the contamination by intravascular signal from tagged blood that flows through the imaging slices. QUIPSS II = quantitative imaging of perfusion using a single subtraction, second version.

RADIANT

MR mammography:
3D reconstruction similar to ultrasound for breast imaging, generates a 360° view with the nipple as the center.

radio frequency (RF)

MR physics: Portion of the electromagnetic spectrum in which electromagnetic waves can be generated by alternating current fed to an antenna. The RF pulses used in MRI are commonly in the 1–100 megahertz range. Their primary effect on the human body is energy dissipation in the form of heat, usually on the surface of the body. Energy absorption is an important value for establishing safety thresholds.

→ **specific absorption rate (SAR)**

radiopharmaceutical

→ **tracer**

ramp time

→ **magnet ramp time**

random

MR-PET examination: Result of coincidence detection in which both participating photons arise from different positron annihilations.

RARE technique

→ **HASTE technique**

raw data

MR measurement: The MR measurement does *not* directly obtain the image. Instead, raw data are generated that are subsequently reconstructed into an image.

raw-data filter

Measurement parameters: Raw data can be filtered prior to image reconstruction.
The **Hamming filter** is provided with various weightings. The filter is able to reduce **edge oscillations**, for example.

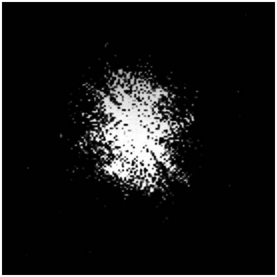
raw-data matrix

MR measurement: As with a hologram, every point in the raw-data matrix contains part of the information for the complete image. This is why a point in the raw-data matrix does not correspond to a point in the image matrix.

The region around the center of the raw-data matrix determines the basic structure and contrast in the image.

The outer region of the raw-data matrix provides information regarding the borders and contours of the image, detailed structures, and also determines the resolution.

Using the two-dimensional Fourier transform, the raw-data matrix is converted into the **image matrix**. For this reason, raw-data lines are also referred to as Fourier lines.



readout bandwidth

Measurement parameters: A pulse sequence's received bandwidth in the **readout direction** (unit: Hz/pixel).

readout direction

MR measurement: The direction in which the MR signal is read out. It corresponds to the direction of **frequency encoding**.

receiver bandwidth

→ **readout bandwidth**

receiver coil

MR components: A local coil that receives signals. Ecxitation is applied via the body coil, the measured signal is the patient-specific signal response.

rectangular FOV (RecFOV)

Measurement parameters: When the object of interest is oval, a rectangular **field of view** can be selected. This applies, for example, to examinations of the abdominal and spinal regions.

The rectangular FOV can be combined with a **reduced measurement matrix**. For example, a rectangular FOV is sampled with an adjusted matrix. A rectangular image is obtained with fewer rows than columns.

The full-resolution raw-data space is sampled less densely, so resolution is not lost. Measurement time is reduced, but so is the signal-to-noise ratio.

reduced matrix

Measurement parameters: When you select fewer lines than columns for the measurement matrix, a reduced matrix results. The high spatial frequencies are no longer measured. This reduces the measurement time. The lines not measured are filled with zeroes prior to image reconstruction (**zero filling**). This corresponds to an interpolation in the phase-encoding direction; therefore, a square image is still displayed on screen.

reference image

Postprocessing: Base image selected for defining the range and orientation of reconstruction methods such as **MIP** or **MPR**.

refocusing

→ **rephasing**

region of interest (ROI)

Postprocessing: An ROI is the area in the MR image singled out for evaluation.

relative cerebral blood flow

Perfusion imaging: The relative cerebral blood flow (relCBF) is the amount of flow corresponding to the relative cerebral blood volume (relCBV).

relative cerebral blood volume

Perfusion imaging: The relative cerebral blood volume (relCBV) is the relative volume taken up by the capillary bed within a voxel, based on the mass of tissue supplied.

relative cerebral blood volume corrected (relCBVCorr)

Perfusion imaging: The perfusion parameter relCBVCorr is the relative cerebral blood volume corrected for the T1 leakage effect of contrast agent.

relative mean transit time

Perfusion imaging: The relative mean transit time (relMTT) is the mean duration of the bolus passage through a voxel. Its pixel-by-pixel display results in a relMTT map.

relaxation

MR physics: Dynamic, physical process where a system returns from a state of imbalance to equilibrium.

→ longitudinal relaxation

→ transverse relaxation

relaxation rate R1, R2, R2*

MR physics: Reciprocals of the relaxation times, T1, T2, and T2*.

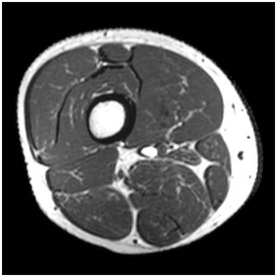
- R1: longitudinal relaxation rate (1/T1)
- R2: transverse relaxation rate (1/T2)
- R2*: apparent transverse relaxation rate (1/T2*)

Relaxation rates provide information about tissue microstructure. Application: quantitative MRI, for example, noninvasive measurement and imaging of liver iron concentrations.

relief artifact

Image quality: Relief-like structures along the transitions between tissue with significant differences in fat and water content (for example, spleen, kidneys, eye sockets, spine, and spinal disks).

The cause is a chemical shift: the signals of the fat and water protons *in a voxel* are allocated to different image pixels during image reconstruction. At transitions of fat and water, these incorrect encodings lead to a higher signal (dark surface area) or to an invalid signal (bright areas) in the respective frequency-encoding direction.



relMTT map

→ relative mean transit time

repetition time (TR)

Measurement parameters: In general, the time between two excitation pulses. Within the TR interval, signals may be acquired with one or more echo times, or one or more phase encodings (depending on the measurement technique). TR is one of the measurement parameters that determines contrast. The acquisition time (TA) is directly proportional to TR.

rephasing

MR physics: Reversal of **dephasing**; the spins go back into phase. Obtained through a 180° pulse that creates a **spin echo**, or a gradient pulse in the opposite direction.

resistive magnet

MR components: Resistive magnet. A magnet whose magnetic field is generated using a normally conductive coil system. When used with copper or aluminum conductors, this system creates a maximum field strength of up to 0.6 tesla. Disadvantage: high electric costs.

resolution

→ **spatial resolution**

→ **temporal resolution**

RESOLVE

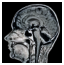
MRI measurement technique: With the RESOLVE method, a multi-shot diffusion-weighted imaging sequence is used which provides an improved image quality compared to standard single-shot echo-planar imaging (ss-EPI). RESOLVE supports all the standard acquisition and data processing features for diffusion imaging (DWI) and diffusion tensor imaging (DTI).

resonance

Physics: Exchange of energy between two systems at a specific frequency. In musical instruments, for example, strings at the same pitch will resonate.

resonance frequency

MR physics: The frequency at which resonance occurs. In MR, this frequency is used for the RF pulse in order to affect the spin equilibrium, that is, it matches the **Larmor frequency** of the spins.



Respiratory Controlled Adaptive k-space Reordering (reCAR)

Cardiac imaging: Technique to improve 4D Flow image quality. Employs phase encoding k-space reordering based on the current respiratory position, in order to increase respiratory gating efficiency for 4D Flow applications. See also **4D Flow MRI**

respiratory gating

Physiologically controlled imaging: Technique for reducing respiratory artifacts. Respiratory gating acquires data only within a predefined window during which the respiratory motion is minimal, for example, in the end-expiration phase. Diaphragm movement may be detected with the **navigator sequence**.

respiratory triggering

Physiologically controlled imaging: Technique for reducing respiratory artifacts. Data acquisition is triggered at a fixed point in the respiratory cycle. Unlike gating, images can be created at any phase of the respiratory cycle.
A respiratory signal acquired with suitable sensors or MR methods (**navigator sequence**) is used as the **trigger signal**.

restore pulse

MRI measurement technique: A 90° RF flip-back pulse at the end of the echo train of a TSE sequence. This rotates the momentary transverse magnetization into the longitudinal axis. This technique allows for a shorter TR with comparable contrast as well as a shorter acquisition times.

retrospective gating

Physiologically controlled imaging: Simultaneous acquisition of untriggered data and the ECG signal. The data acquisition windows, each covering a specific cardiac phase of limited duration, are spread equidistantly across the entire R-R interval. The ECG signal is used during subsequent postprocessing to assign the images to the correct phase in the cardiac cycle.

May also be used for pulsatile flow.

RF adjustment

MRI measurement technique: Adjustment of components prior to the measurement, usually automatic.

→ frequency adjustment

→ transmitter adjustment

RF coil

→ coil

RF energy

→ radio frequency (RF)

RF pulse

→ excitation pulse

RF shielding

Image quality: The radio-frequency pulses used in MR are in the radio frequency range. They have to be shielded for two reasons:

- external electromagnetic waves (for example, radios, electrical machines) would distort the measurement and generate image artifacts
- to avoid interference with other receivers, the RF signals of the system should not extend beyond the system

RF shielding is provided by installing the magnet and receiver coils in a Faraday cage (a space that cannot be penetrated by high-frequency waves). For that purpose, the magnet room is, for example, shielded with copper, and windows are covered with electrically conductive screens.

RF spoiling

MRI measurement technique: Technique for destroying any remaining transverse magnetization after the read-out of the echo and prior to the next excitation.

→ spoiler gradient

rise time

→ gradient rise time

row

→ Fourier line

RX coil

→ receiver coil

R1, R2, R2*

→ relaxation rate R1, R2, R2*

sagittal plane

Slice orientation: Orthogonal plane dividing the body into left (sinister) and right (dexter) parts.

SAR

→ specific absorption rate (SAR)

saturation

MR physics: The state in which spins have no net longitudinal or transverse magnetization. It is not possible to obtain a MR signal from saturated tissue.

saturation recovery (SR)

MRI measurement technique: Technique for generating primarily T1-dependent contrast through a series of 90° excitation pulses. Immediately after the first pulse, longitudinal magnetization is zero because the tissue is saturated. The next 90° pulse is not applied until longitudinal magnetization has partially recovered (recovery).

The recovery time depends on the T1 constant of the tissue.

saturation slice

Slice positioning: Regional presaturation used to suppress undesired signals for specific areas, either within the slice or parallel/perpendicular to it.

→ parallel saturation

→ presaturation

→ tracking sat

scan

MR measurement:

1. Acquiring one or several MR signals after a single excitation pulse

2. Acquiring a complete raw-data record

scatter

MR-PET examination:
A detected pair of photons, at least one of which was deflected from its original path by interaction with matter in the field of view, leading to the pair being assigned to an incorrect line of response (LOR).

scatter correction

MR-PET examination: Scatter correction suppresses effects from scattered coincidences.

scatter fraction (SF)

MR-PET examination: Ratio of scattered true coincidences to the sum of scattered plus unscattered true coincidences.

scout

→ localizer

segmented HASTE

MRI measurement technique: Variant of the standard HASTE technique. With segmented HASTE, half the image information is acquired after the first excitation pulse, and the other half after the second excitation pulse. The raw data, acquired after the first and second excitation pulse, are then interleaved into the raw-data matrix. A long repetition time TR is selected used to allow the spin system to recover between excitation pulses. Any dead time can be used to excite additional slices.

Advantage: The length of the multiecho pulse train is cut in half. HASTE sequences may also be divided into more than 2 segments.

selective excitation

MR measurement: Limits excitation to the region selected. Magnetic field gradients are combined with a narrow-band RF pulse. Selective excitation is also used with fat and water suppression.

SEMAC

MRI measurement technique: Technique to correct for through-plane distortions caused by MR Conditional metal implants by applying additional phase-encoding steps in the slice direction. Image quality is improved, for example, near large metal structures such as full joint replacement of the hip or knee.

SENSE

MRI measurement technique: Image-based parallel acquisition technique (PAT). With SENSE, PAT reconstruction is performed after the **Fourier transform**.

sensitivity

→ **MR sensitivity**

sequence

→ **pulse sequence**

sequential multislice imaging

MRI measurement technique: The slices in the area under examination are measured sequentially.

→ **slice sequence**

shim

Magnetic field: Correction of magnetic field inhomogeneities caused by the magnet itself, ferromagnetic objects, or the patient's body. The basic shim usually involves the introduction of small iron pieces in the magnet.
The patient-related fine shim is software-controlled and performed using a shim coil.

→ active shim

→ global shim

→ interactive shim

→ local shim

→ 3D shim

shim coil

MR components: Coils that create weak additional magnetic fields in various spatial directions. Used to improve the homogeneity in the main magnetic field.

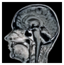
- first order shim: gradient coils are used
- second order shim: specific shim coils are used

shim current

Magnetic field: During shim, shim currents flowing through the system’s shim coils are changed interactively in order to optimize the shim quality.

signal

→ MR signal



signal elimination

Image quality: Areas in the image that do not visualize a signal, that is, they are black. There are different reasons for signal elimination:
Metal artifacts, **susceptibility artifacts**, **flow effects**, and saturation effects.

Flow effects may occur with fast flow when using spin-echo sequences. After half the echo time, the **bolus** has flown out of the slice completely. Since it is no longer acquired by the slice-selective 180° pulse, it no longer produces a spin echo: blood appears black in the image.

signal-to-noise ratio (SNR)

Image quality: Relationship between the intensity of signal and noise. Ways to improve SNR include:

- increasing the number of **averages**
- increasing the measurement volume (although spatial resolution degrades)
- using **special coils** and **local coils**
- smaller **bandwidth**
- shorter **echo time**
- thicker slice

simultaneous excitation

MRI measurement technique: Special averaging procedure that excites two or more slices simultaneously. This enables, for example, more slices to be acquired in the same measurement time.

A simultaneous excitation offers the following advantages:

- shorter TR with the same number of slices, the same measurement time, and the same number of concatenations
- double the number of slices with the same **signal-to-noise ratio** at the same TR and acquisition time

Simultaneous multislice (SMS) imaging

Accelerated MRI: Simultaneous multislice imaging is a three-dimensional parallel imaging method that is particularly suitable for reducing measurement times or acquiring a larger number of slices in the same time. In **parallel imaging**, the amount of data acquired in the phase-encoding direction is reduced (undersampled) and the missing information is provided by the sensitivity profiles of the array elements in the receive coil.

SMS takes this concept a stage further by exciting multiple slices at the same time and spatially encoding their signals in a simultaneous manner.

single

MR-PET examination: Singles are undesired events, which occur when only one of the two photons is detected. Reasons for why singles occur include: one of the two photons leaves the field of view of the detector ring, one of the two photons is scattered or absorbed in the volume to be examined (patient).

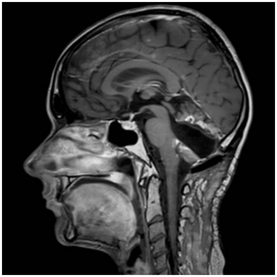
single-bed/single-step examination

MR-PET examination:
An MR-PET examination of a part of the body where the examination region is small enough to make it unnecessary to move the patient table. Bed is the term generally used in the context of PET (positron-emission tomography) while step is the term generally used in the context of MR.

single-shot technique

MRI measurement technique: Uses a single excitation to generate all echoes for an image. The first echoes are encoded via small phase-encoding gradients. Each of the subsequent echoes is given a different phase encoding by increasing the gradient strengths.

Single-shot techniques include: EPI, HASTE.



single Tx mode

Ultra-high field MRI: Operating mode with which a 7T or 11.7T scanner system can be used for clinical diagnostics.

single-voxel spectroscopy

MR spectroscopy:
SVS methods map the metabolic information from the volume of interest (VOI) in a spectrum. Single-voxel techniques are advantageous in case of pathological changes that cannot be spatially limited to a few VOIs: to a large extent, local magnetic field inhomogeneities can be compensated for with a “local volume-sensitive shim”.

Currently, clinical ^{1}H spectroscopy uses single-voxel techniques based on spin echoes (SE) or stimulated echoes (STEAM).

sinogram

MR-PET examination: Two-dimensional display of all one-dimensional projections of an object slice, depending on the projection angle. The projection angle is displayed on the ordinate, the linear projection coordinate is displayed on the abscissa.

slab-boundary artifact

→ slice-boundary artifact

slab thickness

3D imaging: The slice thickness of a 3D slab.

slew rate

→ gradient slew rate

slice

Measurement parameters: Thin, three-dimensional cuboid uniquely defined by slice position, FOV, and slice thickness. The center plane of the slice is the image plane.

slice-boundary artifact

Image quality: Slice-boundary artifacts are caused through signal loss at the boundaries between slices (nonideal slice profile). They appear typically during conventional 3D multi-slab measurements and lead to oscillations in signal intensity and staircase phenomena along the vessels. Also known as slab-boundary artifact, venetian-blind artifact.

slice distance

Measurement parameters: The separation between the center planes of two sequential slices or 3D slabs.

slice gap

Measurement parameters: The gap between the nearest edges of two adjacent slices. Slice thickness + slice gap = slice distance.

slice order

→ **slice sequence**

slice orientation

Measurement parameters: Orthogonal planes are available for use as the basic slice orientation:

- **sagittal**
- **coronal**
- **transverse**

An oblique or double-oblique slice is obtained by rotating the slice out of the basic orientation.

slice position

Measurement parameters: The position of the slice to be measured within the area under examination.

slice positioning

Graphical positioning of the slices and saturation regions to be acquired in a **localizer image**.

slice selection

MR measurement: To display an MR image of the human body, the slice desired has to be selectively excited. For orthogonal slices, a magnetic field gradient is applied perpendicular to the desired slice plane (slice-selection gradient). Oblique and double-oblique slices are excited by simultaneously applying 2 or 3 gradient fields.

slice sequence

Measurement parameters: For multislice measurements, the excitation sequence can be selected as needed:

- ascending (1, 2, 3, ..., *n*)
- descending (*n*, *n*–1, ..., 3, 2, 1)
- interleaved (1, 3, 5, ..., 2, 4, 6, ...)
- freely defined

slice shift

Measurement parameters: Distance between the center of a slice group and the center of the magnetic field in the slice-selection direction.

slice thickness

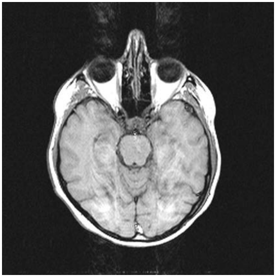
Measurement parameters: The thickness set for the slice to be measured. The thicker the slice, the stronger the signal and the better the **signal-to-noise ratio**. However, **spatial resolution** drops. Combined with the number of slices, this parameter determines the extension of the measurement area in the slice-selection direction.

SMASH

MRI measurement technique: k-space-based method of Parallel Acquisition Technique (**PAT**) With SMASH, PAT reconstruction is performed prior to the **Fourier transform**.

smearing artifact

Image quality: In the case of nonperiodic movements such as eye movement, the excited spins may be at a different location in the gradient field at the time of the echo. This results in incorrect phase encoding. This smears the object in the phase-encoding direction. These artifacts are more discrete for periodic movements (respiration, blood flow).



sodium MRI

MR application: Sodium (23Na) magnetic resonanance imaging can be used to study brain tumors, ischemic stroke, Alzheimerfs diseases and multiple sclerosis. Sodium MRI largely benefits from ultra-high field MRI, such as 7 Tesla. Multichannel array coils can further improve signal-to-noise ratio and improve image quality of sodium MRI.

SPACE

MR measurement technique: The SPACE sequence is a variant of the 3D Turbo spin-echo sequence optimized for 3D data acquisition, 1/T2/PD weighting and dark fluid contrast. Variable flip angles allow for very high turbo factors (>100) and high sampling efficiencies. As a result, high-resolution isotropic images are obtained that allow free reformatting in all planes.

SPACE = Sampling Perfection with Application-optimized Contrast using different flip angle Evolutions

SPAIR

MRI measurement technique: Robust **fat saturation** for body imaging due to a frequency-selective inversion pulse. SPAIR uses an adiabatic pulse which is less sensitive to B1 inhomogeneities.

spatial encoding

MR measurement: Definition of position and orientation of a slice via the **frequency** and **phase-encoding gradient**. Thus, the location of the signals' origin is encoded in the MR signals and reconstructed in subsequent image computations.

spatial filter

Reconstruction parameters: Spatial filter is a parameter for smoothing images. The spatial filter leads to an increase in signal-to-noise ratio at the expense of spatial resolution.

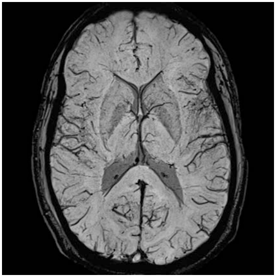
spatial frequency

Physics: The number of repetitions of a periodic process in a unit of space (as opposed to temporal **frequency**).

spatial resolution

Image quality: Is the ability to differentiate neighboring tissue structures. The higher the spatial resolution, the better small pathologies may be diagnosed.

Spatial resolution increases with a larger **matrix**, smaller **FOV**, and smaller **slice thickness**.



spatial shift

Image quality: Spatial shift describes an effect that occurs when superimposed images are not registered correctly. For example, t-maps may be spatially distorted. As a result, superimposed images may not be aligned correctly and need to be checked by superimposing anatomical EPI images or a **field map**.

specific absorption rate (SAR)

Safety: The RF energy absorbed per time unit and per kilogram. Absorption of RF energy can result in warming of the body. Energy absorption is an important value for establishing safety thresholds.

Unauthorized high local concentrations of RF energy can result in burns (local SAR). When the RF energy is uniformly distributed, safety thresholds have to be observed to avoid, for example, cardiac stress (whole-body SAR).

Remedies: low-SAR RF pulses, smaller flip angles, lower TR, fewer slices.

specific energy dose (SED)

Safety: The specific energy dose is the value of the accumulated whole-body SAR throughout the entire examination.

It is expressed in J/kg (= Ws/kg).

spectral map

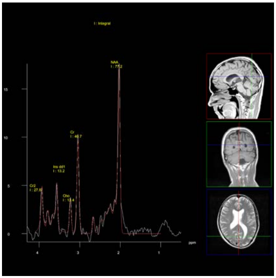
MR spectroscopy: Mapping of a CSI spectral matrix to an anatomical image. It shows the regional changes in metabolites as superimposed contours.

spectroscopy

→ MR spectroscopy (MRS)

spectrum

MR spectroscopy:
The frequency plot of the MR signal. The signal intensity is displayed as a function of the chemical shift. Nuclei with different resonance frequencies appear as separate peaks in the spectrum.



spin

→ nuclear spin

spin density

→ proton density

spin echo (SE)

MRI measurement technique: The reappearance of an MR signal after the decay of the FID signal. Dephasing of the spins (decay of transverse magnetization) is offset through the application of a 180° refocusing pulse. The spins rephase, producing the spin echo at time TE (echo time).

T2* effects (field inhomogeneity, susceptibility) are reversed but *not* T2 effects.

spin-echo chemical-shift imaging (SE-CSI)

MR spectroscopy: Hybrid procedure based on the spin-echo technique.

spin-echo sequence

MRI measurement technique: The sequence of an excitation pulse (90°) and refocusing pulse (180°) produces a spin echo. Can be used to generate T1-weighted, proton-density-weighted or strong T2-weighted images.

spin ensemble

MR physics: Total of all spins in a volume element (voxel) creating the averaged macroscopic magnetization which yields the MR signal for this voxel.

spin-lattice relaxation

→ longitudinal relaxation

spin preparation

MRI measurement technique: Technique to improve or modify the image contrast by applying dedicated preparation pulses, for example, an inversion recovery preparation pulse.

spin-spin coupling

MR spectroscopy: Interaction between MR-sensitive nuclei in a molecule, resulting in additional splitting of peaks in the spectrum.

spin-spin relaxation

→ transverse relaxation

spin-spin relaxation time

→ T2 constant (transverse relaxation time)

spoiler gradient

MRI measurement technique: Gradient pulse with sufficient amplitude, or duration, or both to completely **dephase** the transverse magnetization. The spoiler gradient is applied after the echo so that transverse magnetization is destroyed prior to the next excitation pulse.

Used for **presaturation** and **FLASH sequences**.

SSD

→ **surface-shaded display (SSD)**

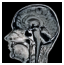
standardized uptake value (SUV)

MR-PET examination:
The standardized uptake value (SUV) is often used in PET imaging for a simple semi-quantitative analysis of the concentration of radioactivity. The SUV represents the ratio of:

- the actual radioactivity concentration found in a selected part of the body at a certain time point, and
- the radioactivity concentration in the hypothetical case of an even distribution of the injected radioactivity across the whole body.

StarVIBE

MRI measurement technique: A motion-insensitive **VIBE sequence** with radial-trajectory acquisition. Supports free-breathing measurements.



steady-state sequence

Sequence technique: Class of fast imaging techniques which keep longitudinal and transverse magnetization constant (steady state). This steady-state magnetization is achieved by repeated excitations with a **repetition time TR** shorter than the **T2 relaxation constant** of the tissue to be imaged.

Types of steady-state sequences include: FISP, CISS, DESS, TrueFISP.

STEAM technique

MR spectroscopy: With the STEAM pulse sequence, 3 slice-selective 90° pulses generate a stimulated echo.

STIR sequence

MRI measurement technique: **Inversion recovery** sequence with a short inversion time TI, used for **fat suppression**.
TI selection depends on the field strength, for example, typical ranges are approx. 150 ms at 1.5 tesla.

stray field

Safety: Magnetic field outside the magnet that does not contribute to imaging; also called fringe field. A specific distance has to be kept between the magnet and various devices and patients with cardiac pacemakers (for example: 0.5 mT line).

The stray field is low with **permanent magnets** because the system is largely self-shielding.

stripe tagging

Cardiac imaging: Technique of **myocardial tagging**, applying parallel stripes in the MR image. Used to view myocardial motion in the primary axis view or four-chamber view.

superconductive magnet

MR components: An electromagnet whose strong magnetic field (typically at least 0.5 T) is generated using superconductive coils. The conductive wires of the coils are made of a cryogenically cooled niobium titanium alloy, for example. Liquid helium is used as the cryogen.

superconductivity

Physics: Material characteristic of various alloys, which at very low temperatures (close to absolute zero) results in a complete loss of electrical resistance. Electrical current can then flow without loss, that is, the magnet is “always on” without any power supply.

surface coil

→ **local coil**

surface-shaded display (SSD)

Postprocessing: Three-dimensional display of surfaces via variable threshold values, of contrast-enhanced vessels, for example.

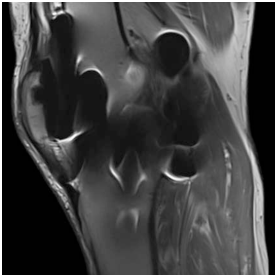
susceptibility (magnetizability)

Physics: Measure for the ability of a material or tissue to be magnetized in an external magnetic field.

susceptibility artifact

Image quality: Local magnetic field gradients are produced in all transitions between tissues of differing magnetic susceptibility. In transitions between tissue and air-filled spaces (for example: the temporal bone), areas may be present that show reduced signal or no signal at all.

The effect is stronger with gradient-echo sequences, in particular EPI.

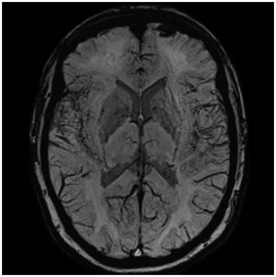


susceptibility contrast

→ T2* contrast

susceptibility-weighted imaging (SWI)

MRI measurement technique: Susceptibility-weighted imaging displays venous vessels as well as hemorrhages in the human brain. The SWI technique is sensitive to local changes in magnetic fields caused by desoxygenated blood or local iron deposits.



swap

→ gradient swap

SWI

→ susceptibility-weighted imaging (SWI)

syngo

Common imaging software for all Siemens modalities.

***syngo* BEAT**

Cardiac imaging: *syngo* tools used to optimize cardiac examinations with a few mouse clicks.

***syngo* BLADE**

MRI measurement technique: The BLADE technique helps reduce the motion sensitivity of MRI examinations:
BLADE is available for the TSE sequence. Each echo train of the sequence generates a low-resolution image with a phase-encoding direction rotated from one excitation to the next. Subsequently, the individual, low-resolution images are combined into a high-resolution image.

syngo BRACE

MR mammography: Methods for motion correction with MR mammography. Eliminates motion artifacts between different measurements in dynamic imaging.

syngo GRACE

MR spectroscopy: GRACE is a SVS procedure in breast spectroscopy, used to quantify the cholin signal.

syngo MR

MR-specific *syngo* application.

syngo NATIVE

MR angiography: Images of arteries and veins without contrast agent (native).

- NATIVE SPACE:
  for peripheral MRA; based on a fast 3D TSE sequence; image data are computed via inline subtraction of two ECG-triggered data sets (systole and diastole).
- NATIVE TrueFISP:
  for thoracic-abdominal MRA (for example: renal arteries). The intrinsic contrast is generated by the inflow of blood with nonsaturated spins into a presaturated volume.

syngo REVEAL

Diffusion imaging: Diffusion-weighted **single-shot technique** for differential diagnosis when evaluating lesions in the overall body; REVEAL may be combined with **2D PACE** technique.

syngo SPACE

MRI measurement technique: SPACE is a variant of the 3D turbo spin echo. As compared with a conventional **TSE** sequence, SPACE uses nonselective, short refocusing pulse trains that consist of RF pulses with variable **flip angles**. This allows for very high **turbo factors** (> 100) and high sampling efficiency. The results are high-resolution, isotropic 3D image data sets which can be reconstructed to slice groups in any desired plane.

syngo TimCT

MRI measurement technique: TimCT (Continuous Table move) enables measurements of large examination regions with continuous table move, that is, in one examination step without measurement pauses or repositioning the table “MR as easy as CT”. Continuous scanning in the **isocenter** of the magnet provides for highest image quality and avoids **slice-boundary artifacts** that may occur with multistation MRI.

syngo TWIST

MRI measurement technique: The TWIST method increases the temporal resolution for angiographic examinations. This is obtained by repeated measurements of the central k-space region. Bolus timing is not required with TWIST. Also consumption of contrast agent is reduced.

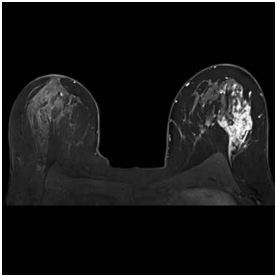
syngo WARP

MRI measurement technique: WARP provides dedicated imaging techniques based on the TSE sequence in order to reduce susceptibility-related artifacts caused by MR Conditional metal implants:

- high bandwidth optimizations (readout bandwidth, RF pulse bandwidth)
- SEMAC
- VAT

syngo VIEWS

MR mammography: Bilateral 3D measurement technique for the breast with fat saturation or water excitation.



tagging

→ myocardial tagging

targeted MIP

→ localized MIP

temporal resolution

Measurement parameters: Time duration between two acquisitions of the same region.

tesla (T)

MR physics: SI unit for magnetic field strength. Approximately 20 000 times as strong as the earth's magnetic field (1 tesla = 10000 gauss).

Test Bolus

Contrast-enhanced MRA: Prior to the actual postcontrast measurement, a small amount of contrast agent is injected at the same injection rate as for subsequent measurements. A rapid 2D measurement, typically 40.80 images with a temporal resolution of one image per second, is used to view the passage of the Test Bolus in the vicinity of the target vessel.

An alternative technique is bolus-tracking **Care Bolus**.

Tim (total imaging matrix)

MR components: Tim is an integrated coil architecture with high-density matrix coils, providing a high signal-to-noise-ratio. Tim allows for whole-body examinations without repositioning the patient.

Example: Tim [204×128]: Tim system up to 204 coil elements and 128 RF channels

time-of-flight angiography (TOF)

MR angiography: The time-of-flight angiography (inflow angiography) visualizes vessels through the flow of non-saturated, fully relaxed blood into the slice, generating a high signal. By comparison, stationary (background) spins are partially saturated and generate a relatively low signal intensity.

time rate of change of the magnetic field

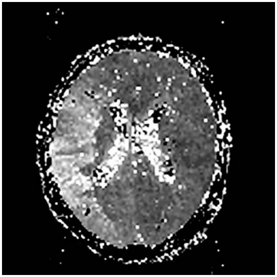
→ dB/dt

time series

Perfusion imaging: The obtained T2* images are labeled with number and time position in the series. They may be used for movie mode and for statistical evaluations.

time-to-peak map (TTP)

Perfusion imaging: A TTP map shows the regional distribution of the time needed to the minimum perfusion signal, either in gray scale or color-coded. It is generated for every slice measured.



TIR sequence

→ turbo inversion recovery (TurboIR, TIR)

TIRM sequence

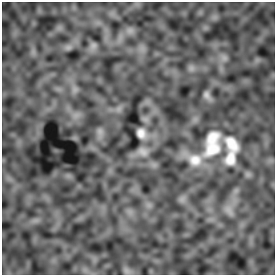
→ turbo inversion recovery magnitude (TIRM)

tissue contrast

→ image contrast

t-map

BOLD imaging: When evaluated with the t-test, the t-map shows a statistical correlation of the signal intensity change with the paradigm. Positive correlations between stimulation and signal increase in BOLD images are shown bright, negative correlates are shown dark.

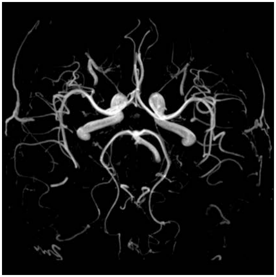


TOF angiography

→ time-of-flight angiography (TOF)

TONE technique

MRI measurement technique: TONE is used for TOF angiography to minimize the saturation effects as blood flows through a 3D volume. An RF pulse with a tilted slab profile compensates for the velocity and direction of blood flow. This generates a flip angle that varies from partition to partition.



total imaging matrix

→ Tim (total imaging matrix)

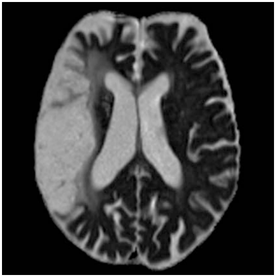
tracer

MR-PET examination:
A tracer is a substance that is used to monitor certain metabolic pathways without macroscopic effects (that is, tracers are administered in very small quantities and are often labeled, for example, with fluorescent dyes, positron emitters, etc.) A *PET tracer*, in particular, is a tracer labeled with a positron emitter with a half-life suitable for PET imaging.

trace-weighted image

Diffusion imaging:
In trace-weighted images, contrast is generated by the length of the diffusion tensor and reflects the mean diffusivity. This corresponds to the sum of diagonal elements (trace) of the diffusion tensor matrix:

$$\text{Trace} = D_{xx} + D_{yy} + D_{zz}$$



tracking sat

Slice positioning: A presaturation pulse is applied to one side of the slice to reduce the signal intensity of spins (typically blood) that are about to flow into this side of the slice. This enables arteries or veins to be displayed selectively, since the flow is often in the opposite direction (for example, carotid artery and jugular vein).

The slices are measured sequentially (slice by slice). The presaturation pulse retains its position relative to the slice.

tractography

→ diffusion tractography

trajectory

→ k-space trajectory

transceiver coil

MR components: A local coil that both sends and receives signals.

transit time

Contrast-enhanced examination: The transit time is the time of contrast bolus arrival in the region of interest after contrast agent injection.

transmission bandwidth

MR measurement: The frequency range stimulated by the **excitation pulse** in a sequence.

transmit coil

MR components: A local coil that sends excitation pulses.

transmitter adjustment

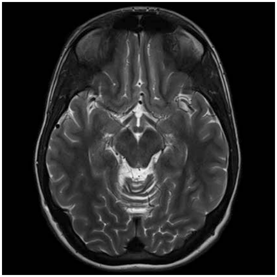
MR measurement: Setting the transmission power of the RF pulse (**flip angle**).

transverse magnetization (M_{xy})

MR physics: Transverse magnetization M_{xy} is the component of the macroscopic magnetization vector in the xy-plane; that is, oriented perpendicular to the stationary magnetic field B0. The precession of transverse magnetization induces electrical voltage in a receiver coil that changes over time. The temporal progression of this voltage is the MR signal. After RF excitation, M_{xy} decays to zero at time constant T2 (ideal) or T2* (real).

transverse plane

Slice orientation: Orthogonal plane dividing the body into cranial (head, superior) and caudal (feet, inferior) parts. Synonym: Axial plane.



transverse relaxation

MR physics: Decay of transverse magnetization through the loss of phase coherence between precessing spins (due to spin exchange); is also known as spin-spin relaxation.

transverse relaxation time

→ T2 constant (transverse relaxation time)

trigger

Physiologically controlled imaging: Reference point in the physiological signal which releases the scan, for example, the R wave in the ECG signal.

trigger delay time (TD)

ECG triggering: Interval between the trigger and release of the measurement.

triggering

Physiologically controlled imaging: Triggering is a form of measurement where MR data acquisition only begins after detection of a desired physiologic event (R-wave, peripheral pulse, specified level of inspiration, or external trigger).

trigger signal

Physiologically controlled imaging: Physiological signal (ECG signal, finger pulse or respiratory curve) that starts or restarts data acquisition.

true

MR-PET examination: When the tracer decays it emits a positron. As a result of the positron annihilation, two photons are emitted at an angle of 180°. If these two photons are detected within the coincidence window, a **line of response (LOR)** is reconstructed. This is a true or true event.

trueFISP

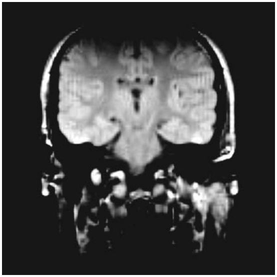
MRI measurement technique: The TrueFISP gradient-echo sequence provides the highest signal of all steady-state sequences. The contrast is a function of T1/T2. However, with a short TR and a short TE, the T1 portion remains constant. The images are primarily T2-weighted.

The FISP and PSIF signal are generated simultaneously. Due to the superimposition of both signals, TrueFISP is sensitive to inhomogeneities in the magnetic field. The images may contain interference stripes. For this reason, TR should be as short as possible, and a **shim** has to be performed.

truncation artifact

Image quality: MR images frequently show periodic oscillations parallel to tissue transitions. The artifacts show bands with alternating high and lower signal intensity. All abrupt transitions in tissue are subject to this effect.

The artifact is created through point-by-point sampling of the analog signal. Theoretically, an infinite number of points would have to be sampled. In practical application, however, there is a finite number of points: the data are truncated.



TTP map

→ time-to-peak map (TTP)

t-test

BOLD imaging: Statistical evaluation method for BOLD measurements (previously Z-score). Is used to compute the differential image from the mean values of activation and nonactivation images. Today, the t-test is integrated in GLM.

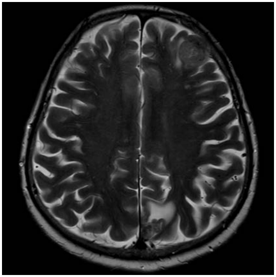
turbo factor

Measurement parameters: Measurement time saved using a TSE sequence rather than a conventional spin-echo sequence.

Example: At a turbo factor (echo train) of 7, the TSE sequence measures 7 times faster than an SE sequence with comparable parameters.

turboFLASH

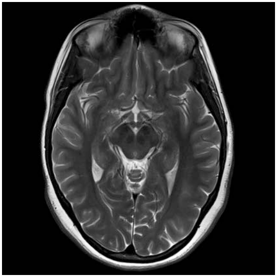
MRI measurement technique: With a TurboFLASH sequence, the entire raw-data matrix is measured in one acquisition only with an ultra-fast gradient-echo sequence. The image contrast is modified via preparation pulses.



turbo gradient spin echo (TurboGSE, TGSE)

MRI measurement technique: TurboGSE is a hybrid sequence, derived from TSE and EPI. With TGSE, additional gradient echoes are generated before and after each spin echo. The spin echoes are allocated to the center of the raw-data matrix to give pure T2 contrast. The gradient echoes are allocated to the outer segments. Gradient echoes determine mainly the image resolution.

Advantages as compared with TSE: they are faster, fat is darker, greater sensitivity to susceptibility effects (for example: bleeding with hemosiderin).



turbo inversion recovery (TurboIR, TIR)

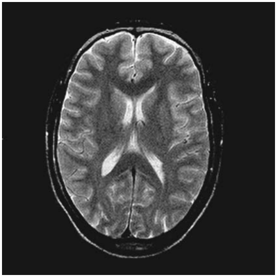
MRI measurement technique: TSE sequence with inversion pulse; long TI for fluid suppression (**FLAIR**); short TI for fat suppression (**STIR**).

turbo inversion recovery magnitude (TIRM)

MRI measurement technique: Identical to TurboIR, however, with the magnitude image of the signal and appropriate display.

turbo spin echo (TurboSE, TSE)

MRI measurement technique: TSE is a fast multiecho sequence. Each echo of a pulse train receives a different phase encoding. Within one repetition time TR, raw-data rows equal to the number of pulse train echoes are acquired (segmented raw data).
The **turbo factor** increases speed, and is frequently used to improve resolution.



TWIST-VIBE

MRI measurement technique: **VIBE sequence** which is extended by the **TWIST** technique in combination with **CAIPIRINHA** and **Dixon** with fat/water separation. This allows multi-arterial phase imaging in a single breathhold with high temporal and spatial resolution. Contrast agent timing is not required as the arterial phase is covered from the beginning of the measurement.

Tx coil

→ transmit coil

TxRx coil

→ transceiver coil

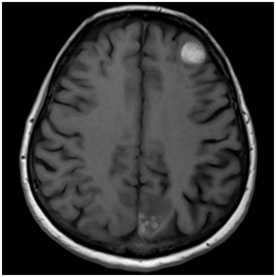
T1 constant (longitudinal relaxation time)

MR physics: Tissue-specific time constant which describes the return of the longitudinal magnetization to equilibrium. After time T1, the longitudinal magnetization grows back to approx. 63 % of its end value. A tissue parameter that determines contrast.

T1 contrast

Image quality: Since different types of tissue show different T1 relaxation, this difference can be shown as image contrast (T1 weighting).

Rule of thumb: T1 contrast = TR short (to maximize T1 contrast), TE short (to minimize T2 contrast).



T1 weighting

→ T1 contrast

T2 constant (transverse relaxation time)

MR physics: Tissue-specific time constant that describes the decay of transverse magnetization in an ideal homogeneous magnetic field. After time T2, transverse magnetization has lost 63 % of its original value. A tissue parameter that determines contrast.

T2 contrast

Image quality: Since different tissue types show different T2 relaxation, these differences are shown as image contrast (T2 weighting).

Rule of thumb: T2 contrast = TR long (to minimize T1 contrast), TE long (to maximize T2 contrast).

T2 weighting

→ T2 contrast

T2* constant

MR physics: Characteristic time constant that describes the decay of transverse magnetization, taking into account the inhomogeneity in static magnetic fields and the human body. T2* is always less than T2.

T2* contrast

Image quality: The contrast of a T2*-weighted image depends primarily on the various T2* time constants of the different tissue types.

Ultra-high field magnet

MR technology: MR magnet with very high field strength, starting with 7T. The stronger magnetic field enhances contrast and image resolution, allowing for new research and clinical applications. Systems with a field strength of 9.4T and 11.7T have become available.

UTE

MRI measurement technique: Pulse sequences with ultrashort **echo times** (UTE) that are 10 to 20 times shorter than conventional ones. This allows for the display of tissue components with a short T2 (for example, membranes, compact bone substance) that could appear as dark only due to their small signal portion.

VAT

MRI measurement technique: Technique to correct for in-plane distortions.
During signal readout, an additional readout gradient (VAT gradient) is applied along the slice-selection direction. This gradient causes "shearing" of the imaged pixels, as if the slice were viewed at an angle. Hence, the pixel shift in the readout direction is compensated.

However, VAT may cause image blurring due to geometric slice shear as well as the low-pass filtering effect of the additional VAT gradient. These effects can be minimized by using thinner slices, higher resolution, and shorter readout durations.

Application: reduction of artifacts in the presence of MR Conditional metal implants.

velocity encoding

Measurement parameters: The velocity encoding (venc) parameter is used to produce the phase shift known as flow sensitivity in phase-contrast images.

venc

→ velocity encoding

venetian-blind artifact

→ slice-boundary artifact

VERSE

MRI measurement technique: Sequences with time-optimized VERSE pulses improve the slice profile for 3D measurements. This allows for the accelerated 3D imaging of limited volumes with a consistent image contrast across the entire **3D slab**.

VIBE

MRI measurement technique: FLASH 3D imaging technique with reduced data acquisition time by using data interpolation, or partial Fourier techniques, or both, primarily for dynamic contrast-enhanced examinations of the abdomen.

VIBE-Dixon

MR measurement technique: Combines 3D T1-weighted GRE sequence VIBE and the Dixon fat-water separation approach. Based on the acquisition of an in- and opposed-phase 3D T1-weighted GRE dataset in one breath-hold, both water images and fat images are automatically calculated. The VIBE Dixon technique can be applied for Fat Quantification and R2* assessment with the LiverLab package.

volume coil

MR components: An RF coil that encloses a part of the body (for example: head/neck coil, knee coil).

volume of interest (VOI)

A VOI is the volume used for measurements or evaluations.

volume-rendering technique

→ 3D VRT

voxel

Imaging: Volume element of the sample to be examined which is assigned to a pixel in the image matrix.

Voxel size = slice thickness × pixel size

→ spatial resolution

voxel bleeding

MR spectroscopy: Voxel bleeding indicates crosstalk of signal intensities from one voxel to an adjacent voxel. Up to 10 % of a signal can appear in an adjacent voxel. These localization artifacts tend to appear in the image during intensity tests. It is reduced by an apodization filter (for example: Hamming filter).

VRT

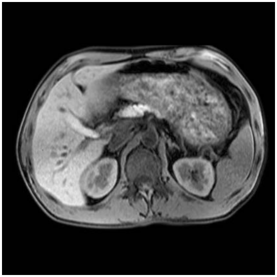
→ 3D VRT

wash-out effect

Image quality: The wash-out effect can appear perpendicular to the image plane during fast flow. It occurs during spin-echo imaging and similar procedures. Using a 90° pulse, a bolus is excited within the slice to be measured. If blood flows out of the slice before the subsequent 180° pulse, some or all of the signal is lost. This results in a low signal or no signal at all.

water image

Image quality: A pure water image displays only the signals from water protons in the image and suppresses signals from fat protons. Water images are generated with the **dixon** technique, for example.
See also **fat image**.



water saturation

Image quality: Frequency-selective excitation of water, with subsequent dephasing, is used to suppress water signals. This technique is used for MR imaging and spectroscopy.

water suppression

Image quality: The MR signal comprises the sum of signals from water and fat protons. Various techniques can be used to suppress the water signal.

→ water saturation

wave image

MR elastography: Image obtained by the application of mechanical waves generated by an acoustic driver system, performed during measurement with a motion-sensitive MR sequence. The wave image is used to calculate an elastogram. See also elastogram

Wave-CAIPI

MR measurement technique: Acceleration technique for susceptibility-weighted imaging (SWI). Wave-CAIPI combines the CAIPIRINHA acceleration method with a Wave trajectory.

whisper sequence

MRI measurement technique: Sequences with low acoustic noise gradient pulses.

whole-body MRI examination

MRI measurement technique: Imaging the whole body of a patient in one single examination. Strategies used are **multistation** MRI or acquisition during continuous table movement (see **syngo TimCT**).

whole-body SAR

Safety: Specific absorption rate (SAR) averaged over the total mass of the patient's body and over a specified time.

width

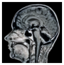
→ **windowing**

windowing

Image display: Setting brightness (center) and contrast (width) in images.

wrap-around artifact

→ **overfolding artifact**



zero filling

MRI measurement technique: Interpolation technique for expanding a **raw-data matrix** with zeroes. Commonly used to increase the image matrix size in the phase-encoding direction (for example, from 256 to 512) or in the slice-encoding direction for 3D measurements (for example, from 32 to 64)

Z-score

→ **t-test**

1D PACE MRI measurement technique: Fast motion correction in real time, for example, during cardiac imaging. This PACE technique allows the patient to breathe freely during the measurement.

1Tx mode → **single Tx mode**

2D PACE MRI measurement technique: The PACE technique used in abdominal imaging is based on a local 2D test image for motion detection.

23Na imaging → **sodium MRI**

3D ASL Perfusion imaging: 3D **arterial spin labeling** includes inline calculation of perfusion-weighted maps for a qualitative evaluation of perfusion.

3D imaging MRI measurement technique: In 3D imaging, the entire measurement volume, the 3D slab, is excited and not just single slices. Additional phase encoding in the slice-selection direction provides information in this direction. See also **partition**.

3D PACE

MRI measurement technique: Fully automated technique for motion detection and correction during BOLD measurements. Serves to eliminate motion artifacts.

3D PACE corrects
6 degrees of freedom (3 translations and
3 rotations) in real time.

3D shim

Magnetic field: 3D shim enables the shim volume to be limited (**local shim**). A 3D volume (VOI) is defined. The local magnetic field distribution is determined in this volume, resulting in the calculation of the shim currents.

A 3D shim provides for a more precise result than a MAP shim used with older MR systems and therefore for a better fat saturation. For spectroscopy, it provides a better starting value for the interactive shim.

3D slab

Measurement parameters: Measurement volume stimulated for 3D imaging. The 3D slab is divided into **partitions**.

3D TSE

MRI measurement technique: As a 3D sequence, TSE allows for the acquisition of T2 images with thin slices and practically uniform voxels.

3D VRT

Postprocessing: 3D depiction of complex anatomies and anatomic relationships, for example, in angiography. In addition to color images, a threshold-based segmentation of 3D objects is possible.

31P MRS

MR spectroscopy: Analytical chemistry technique that uses nuclear magnetic resonance to study chemical compounds that contain phosphorus. 31P MRS acquires information about the most important energy carriers of cells, such as ATP, creatine phosphate, and inorganic phosphate.

4D flow measurement

MR measurement technique: Flow measurement using navigator-based respiratory gating techniques combined with ECG triggering to acquire 4D flow data of the heart and the aorta.

4D Flow MRI

Cardiac imaging: Provides comprehensive evaluation of cardiovascular hemodynamics by acquiring threedimensional data combined with time-resolved velocity encodings in all three spatial directions. Due to its long acquisition time, respiratory gating is normally used to mitigate breathing artifacts (blurring, ghosting) for thoracic and abdominal applications.

4D MRI

MR measurement: MRI method for motion imaging and correction.

AC	attenuation correction
ACRIN	American College of Radiology Imaging Network
ADC	analog-to-digital converter
ADC	apparent diffusion coefficient
AIF	arterial input function
AS	active shielding
ASL	arterial spin labeling
ATC	activity-time course
b	b-value
B	magnetic induction, MR: magnetic field
BAT	bolus arrival time
BOLD	blood oxygenation-level-dependent imaging
bpMRI	biparametric MRI
BRACE	breast acquisition correction
$\mathbf{B_0}$	main magnetic field
$\mathbf{B_1}$	alternating magnetic field

CAIPIRINHA controlled aliasing in parallel imaging results in higher acceleration

CASL continuous arterial spin labeling

CARE combined applications to reduce exposure

CB Care Bolus

CE MRA contrast-enhanced MR angiography

CISS constructive interference in steady state

CM contrast medium, contrast agent

CMRA coronary MR angiography

CMRI cardiac MRI

CNR contrast-to-noise ratio

CP circular polarization

CPR curved planar reconstruction

CS compressed sensing

CSF cerebrospinal fluid, liquor

CSI chemical-shift imaging

CSPAMM complementary spatial modulation of magnetization

dB/dt temporal change of the magnetic field

DENSE displacement encoding with stimulated echoes

DESS dual echo steady state

DIR double inversion recovery

DL deep learning

DICOM digital imaging and communication in medicine

DR deep resolve

DSI diffusion spectrum imaging

DTI diffusion tensor imaging

DWI diffusion-weighted imaging

EPI echo-planar imaging

FA	flip angle
FA	fractional anisotropy
FAIR	flow-sensitive alternating inversion recovery
FatSat	fat saturation
FDG	fluorodeoxyglucose
FFT	fast Fourier transform
FID	free induction decay
FISP	fast imaging with steady state precession
FLAIR	fluid attenuated inversion recovery
FLASH	fast low angle shot
fMRI	functional magnetic resonance imaging
FOR	frame of reference
FOV	field of view
FT	Fourier transform
FWHM	full width at half maximum (peak)
GBP	global bolus plot
GLM	general linear model
GMR	gradient motion rephasing, flow compensation
GRACE	generalized breast spectroscopy exam
GRAPPA	generalized autocalibrating partially parallel acquisition
GRASE	gradient and spin echo
GRASP	golden-angle radial sparse parallel MRI
GRE	gradient echo
GSP	graphical slice positioning

HASTE half-Fourier acquisition single-shot TurboSE

HIPAA Health Insurance Portability and Accountability Act

HUGE homogenization using gradient enhancement

Hz hertz

IDEA integrated development environment for applications

iGRASP iterative golden-angle radial sparse parallel MRI

iMRI interventional magnetic resonance imaging

IPA integrated panoramic array

iPAT integrated parallel acquisition techniques

IR inversion recovery

IRM inversion recovery magnitude

IRT interactive real-time

IRTTT interactive real-time tip tracking

LOR line of response

LOTA long term averaging

MAP	multiangle projection
MDDW	multidirectional diffusion weighting
MEDIC	multiecho data-image combination
MIP	maximum intensity projection
mIP / MinIP	minimum intensity projection
MNS	multinuclear spectroscopy
mpMRI	multiparametric MRI
MPPS	modality performed procedure step
MPR	multiplanar reconstruction
MPRAGE	magnetization prepared rapid gradient-echo imaging
MR	magnetic resonance
MRA	magnetic resonance angiography
MRE	magnetic resonance elastography
MRF	magnetic resonance fingerprint-ing
MRI	magnetic resonance imaging
MRAC	MR-based attenuation correction
MRBBY	magnetic resonance breast biopsy
MRE	magnetic resonance eleastogra-phy
MRF	magnetic resonance fingerprint-ing
MRS	magnetic resonance spectroscopy
MRSI	magnetic resonance spectroscopic imaging
mSENSE	modified sensitivity encoding
ms-EPI	multishot EPI
MTC	magnetization transfer contrast
mT/m	millitesla per meter
MTT	mean transit time
M_{xy}	transverse magnetization
M_Z	longitudinal magnetization

NA number of acquisitions

NEMA National Electrical Manufacturers Assocation

NOE nuclear Overhauser effect

NMR nuclear magnetic resonance

OVS outer volume suppression

PACE prospective acquisition correction

PASL pulsed arterial spin labeling

PAT parallel acquisition techniques

PBP percentage of baseline at peak

PCA phase-contrast angiography

PCASL pseudo continuous arterial spin labeling

PERU physiological ECG and respiratory unit

PET positron emission tomography

PETRA pointwise encoding time reduction with radial acquisition

PMU physiological measurement unit

PNS peripheral nerve stimulation

POCS projection onto convex sets

ppm parts per million

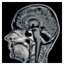
PPU peripheral pulse unit

PRESS point resolved spectroscopy

PSIF FISP read backward

pTx parallel transmission

PWI perfusion-weighted imaging



QA quality assurance

QISS quiescent interval single shot

qMRI quantitative MRI

QUIPSS quantitative imaging of perfusion using a single subtraction

RARE rapid acquisition with relaxation enhancement

ReCAR respiratory controlled adaptive k-space reordering

relCBF relative cerebral blood flow

relCBV relative cerebral blood volume

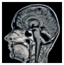
relCBVCorr relative cerebral blood volume corrected

relMTT relative mean transit time

RF radio frequency

ROI region of interest

SAR	specific absorption rate
SE	spin echo
SE-CSI	spin-echo chemical-shift imaging
SED	specific energy dose
SEMAC	slice-encoding for metal artifact correction
SENSE	sensitivity encoding
SF	scatter fraction
SFC	static field correction
SI	système internationale
SMASH	simultaneous acquisition of spatial harmonics
SMS	simultaneous multislice
SNR	signal-to-noise ratio
SPACE	sampling perfection with application-optimized contrast using flip angle evolutions
SPAIR	spectrally adiabatic inversion recovery
SR	saturation recovery
SSD	surface-shaded display
STEAM	stimulated echo acquisition method
STIR	short TI inversion recovery
SUV	standardized uptake value
SVS	single-voxel spectroscopy
SWI	susceptibility-weighted imaging



T	tesla
TA	acquisition time
TD	delay time
TE	echo time
TE_{eff}	effective echo time
TGSE	turbo gradient spin echo
TI	inversion time
Tim	total imaging matrix
TimCT	Tim continuous table move
TIR	turbo inversion recovery
TIRM	turbo inversion recovery magnitude
TOF	time of flight
TONE	tilted, optimized, nonsaturating excitation
TR	repetition time
TR_{eff}	effective repetition time
TSE	turbo spin echo (TurboSE)
tseff	effective stimulus duration
TTP	time to peak

UHF	ultra-high field
UTE	ultrashort TE
VAT	view angle tilting
venc	velocity encoding
VERSE	variable-rate selective excitation
VIBE	volume interpolated breath-hold examination
VIEWS	volume imaging with enhanced water signal
VOI	volume of interest
VRT	volume-rendering technique

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