

***Signa LX Release 9.0
New Features Manual***

2298978-100 Rev. 1 (10/01)

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Medical Device Directive

These products conform with the requirements of council directive 93/42/EEC concerning medical devices, when they bear the following CE Mark of Conformity:



This equipment generates, uses, and can radiate radio frequency energy. The equipment may cause radio frequency interference with other medical and non-medical devices and radio communications. To provide reasonable protection against such interference, the:

GE Signa® MR/i Systems

comply with emissions limits for (Group 2, Class A) Medical Devices as stated in EN 60601-1-2. However, there is no guarantee that interference will not occur in a particular installation.



If this equipment is found to cause interference (which may be determined by turning the equipment on and off), the user (or qualified service personnel) should attempt to correct the problem by one or more of the following measure(s):

- reorient or relocate the affected device(s);
- increase the separation between the equipment and the affected device;
- power the equipment from a source different from that of the affected device; and/or
- consult the point of purchase or service representative for further suggestions.

The manufacturer is not responsible for any interference caused by using interconnect cables that are not recommended or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

Do not use devices that transmit RF Signals (**cellular phones**, transceivers, or radio controlled products) in the vicinity of this equipment as they may cause performance outside the published specifications. Keep the power to these types of devices turned off when near this equipment.

The medical staff in charge of this equipment is required to instruct technicians, patients, and other people who may be around this equipment to fully comply with the above requirement.

Immunity/Emissions Exceptions: Note the exceptions from the EMC test results. Check with the business EMC engineer for this information.

In accordance with the international safety standard IEC 601-1, this system is a Class I device, acceptable for Continuous Operation, having ordinary protection against ingress of water with type B applied parts and is not for use in the presence of flammable anesthetics.

CAUTION: User to call or contact the local authorities for disposal of the MR System and its components at the end of its useful life.

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Chapter 1

About This Guide

Introduction

This chapter explains the purpose and design of this Learning and Reference Guide. It is an introduction to the guide, providing information on the purpose, prerequisite skills, guide organization, chapter format, and graphic conventions that identify the visual symbols used throughout the guide.

Safety Information

Please refer to the “Working Safely” chapter in Volume 1 of your MR system’s Learning and Reference Guide. The “Safety” chapter describes safety information you and the physician must understand thoroughly before you begin to use the system. Note that you will find additional safety information throughout your Learning and Reference Guides. If you need additional training, seek assistance from qualified GE Medical personnel.

The equipment is intended for use by qualified personnel only.

This guide should be kept with the equipment and be readily available at all times. It is important for you to periodically review the procedures and safety precautions. **It is important for you to read and understand the contents of this guide before attempting to use this product.**

The following Cautions and System Maintenance section is additional information not in your system’s Learning and Reference Guide.

System Maintenance

Background cleaning should be done by site personnel (e.g., technologists or housekeeping personnel) unless otherwise indicated in the following maintenance schedules.

Cleaning tips:

- To clean most accessories, use nothing stronger than alcohol or a mild soap and water solution.
- Use hydrogen peroxide to remove bloodstains.
- Open cell sponges are coated with canvas to allow better durability and reliability. These sponge covers allow disinfection using only 5.25% sodium hypochlorite diluted between 1:10 and 1:100 with water and 10% bleach solution. Anything else may discolor the fabric.



CAUTION: To avoid possible damage to equipment, do not use solutions containing amines, strong alkalis, esters, iodine, aromatic or chlorinated hydrocarbons, or ketones. Do not use autoclaves or the industrial washers and dryers found in most hospitals or professional laundry services.

Clinical Hazards



CAUTION: Following the exam, your patient may need assistance when getting off the table. After lying in a prone position for a length of time, your patient may experience light-headedness upon sitting up.

Purpose of This Guide

This guide is written for health care professionals (namely, the MR technologist) to provide the necessary information relating to the proper operation of this system. The guide is intended to teach you the system components and features necessary to use it to its maximum potential. It is not intended to teach magnetic resonance imaging or to make any type of clinical diagnosis.

Prerequisite Skills

This guide is not intended to teach magnetic resonance imaging. It is necessary for you to have sufficient knowledge to competently perform the various diagnostic imaging procedures within your modality. This knowledge is gained through a variety of educational methods including clinical working experience, hospital based programs, and as part of many college and university Radiologic Technology programs.

Chapter Format

Each chapter contains a consistent format. This consistency provides uniformity for content delivery and a better learning environment for you. Listed below are the components for each chapter.

Introduction

The **Introduction** provides a short introduction to the chapter and a list of tasks to be presented. There are pre-questions related to the concepts and tasks of the chapter. These pre-questions help you think about the concepts and tasks as you go through a particular chapter and help reinforce the learning of the material covered.

What Do I Need to Know About...

The **What Do I Need to Know About...** section lists and explains concepts necessary to perform the tasks within the chapter.

How Do I...

The **How Do I...** section provides the detailed steps necessary to complete a given task. These detailed steps not only provide the steps to complete a task, but also provide additional information, as needed, related to a step.

On the first page of each task, there is an **In Brief** table in the outer margin. This **In Brief** table is intended to be used as a quick reference by the experienced technologist and provides only the steps necessary to complete a task.


Graphic Conventions and Legend

The format of the page is such that you have room in the outer margin to make notes as needed, except in the area where the **In Brief** table is located in the **How Do I...** section. Table 1-1 describes the terminology used for the various mouse functions. Table 1-2 describes the conventions used when working with menus, buttons, text boxes and keyboard keys.

Table 1-1 Conventions for Mouse Actions

Mouse Action	Description
Click	Clicking the left mouse button to select a button or icon. The button can be pressed in, not pressed in, or popped in/out.
Right-click	Clicking the right mouse button.
Middle-click	Clicking the middle mouse button.
Click and drag	Clicking and holding the left mouse button down while dragging the cursor to the desired location.
Right-click and drag	Clicking and holding the right mouse button down while dragging the cursor to the desired location.
Middle-click and drag	Clicking and holding the middle mouse button down while dragging the cursor to the desired location.
Double-click	Clicking the left mouse button twice in rapid succession.
Triple-click	Clicking the left mouse button three times in rapid succession.

Table 1-2 Conventions for Menus, Buttons, Text Boxes, and Keyboard Keys

Example	Describes
Select	Selecting an option in a check box or radial button and selecting a tab.
Press Enter	Pressing a hard key on the keyboard.
Press and hold Shift	Pressing and holding down a hard key on the keyboard.
Click [Viewer]	A button label or Interface button name.
Click  (Exam prior)	Selecting an icon-based button.
In the Matrix text box,...	The name of text box in which you can select or type text.
Type supine in the Patient Position text box (different font and bold)	Text you enter into a text box.
Select Sort > Sort by date	The pathway of selecting option(s) in a pull-down menu.

Safety Notices

The following safety notices are used to emphasize certain safety instructions. This guide uses the international symbol along with the danger, warning, or caution message. This section also describes the purpose of a Note.



DANGER: Danger is used to identify conditions or actions for which a specific hazard is known to exist which will cause severe personal injury, death, or substantial property damage if the instructions are ignored.



WARNING: Warning is used to identify conditions or actions for which a specific hazard is known to exist which may cause severe personal injury, death, or substantial property damage if the instructions are ignored.



CAUTION: Caution is used to identify conditions or actions for which a potential hazard may exist which will or can cause minor personal injury or property damage if the instructions are ignored.

NOTE: A Note provides additional information that is helpful to you. It may emphasize certain information regarding special tools or techniques, items to check before proceeding, or factors to consider about a concept or task.

Chapter 2

New Features

Introduction

This chapter presents an overview of the Signa® LX 9.0 new and enhanced features. It contains information to complement the Signa® MR/i™ with Signa Select™ (ASP2) Learning and Reference Guide.

Safety Information

Please refer to the “Working Safely” chapter in Volume 1 of your Learning and Reference Guide. The Safety chapter describes safety information you and the physician must understand thoroughly before you begin to use the system. Note that you will find additional safety information throughout your Learning and Reference Guides. If you need additional training, seek assistance from qualified GE Medical personnel.

The equipment is intended for use by qualified personnel only.

Make sure all of your Learning and Reference Guides are readily available at all times. Be sure to review the procedures and safety precautions periodically.

System Maintenance

Background cleaning should be done by site personnel (e.g., technologists or housekeeping personnel) unless otherwise indicated in the following maintenance schedules.

Cleaning tips:

- To clean most accessories, use nothing stronger than alcohol or a mild soap and water solution.
- Use hydrogen peroxide to remove bloodstains.

- Open cell sponges are coated with canvas to allow better durability and reliability. These sponge covers allow disinfection using only 5.25% sodium hypochlorite diluted between 1:10 and 1:100 with water and 10% bleach solution. Anything else may discolor the fabric.



CAUTION: To avoid possible damage to equipment, do not use solutions containing amines, strong alkalis, esters, iodine, aromatic or chlorinated hydrocarbons, or ketones. Do not use autoclaves or the industrial washers and dryers found in most hospitals or professional laundry services.

Clinical Hazards



CAUTION: Following the exam, your patient may need assistance when getting off the table. After lying in a prone position for a length of time, your patient may experience light-headedness upon sitting up.

Indications for Use - *TwinSpeed*

The Signa 1.5T *TwinSpeed™* Magnetic Resonance System is a whole body scanner designed for shorter scan times. The Signa *TwinSpeed* is indicated for use as a diagnostic imaging device to produce transverse, sagittal, coronal and oblique images of the internal structures of the head or body. The images produced by this system reflect the spatial distribution of protons (hydrogen nuclei) exhibiting magnetic resonance. The NMR properties that determine the image appearance are proton density, spin-lattice relaxation time (T1), spin-spin relaxation time (T2) and flow. When interpreted by a trained physician, these images provide information that can be useful in determining a diagnosis.

Gradient, Shim, and Imaging Coils

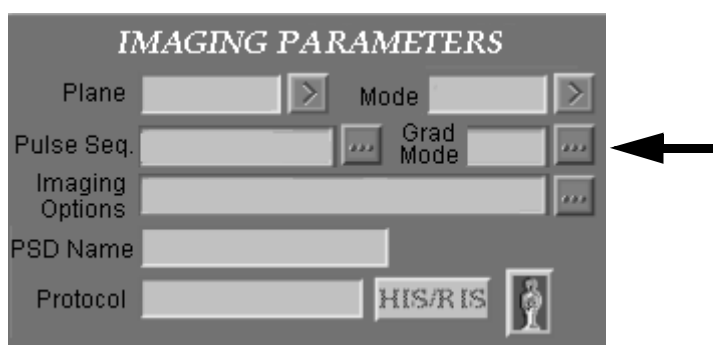
The *TwinSpeed™* Resonance Module (TRM) is 60 cm in diameter and consists of two actively shielded gradient coils. One gradient coil can be used for whole body imaging and the second for smaller optimized field of view (FOV) advanced applications.

The system is optimized to operate in two imaging modes.

- Zoom gradient mode
 - A single coil is active in a given pulse sequence
 - Intended for small FOV applications
- Whole Body gradient mode
 - A single coil is active in a given pulse sequence
 - Intended for large FOV applications

You can select the active imaging mode in between sequences during scan prescription. The **Grad Mode** text box in the Imaging Parameters area (Figure 2-1) allows you to select the appropriate imaging mode (toggles between the Zoom or Whole Body modes). You can change the mode for each specific application with the help of this text box.

Figure 2-1 Imaging Parameters Area



After selection of gradient mode, the system automatically calculates the available range of echo time (TE), repetition time (TR), slice widths, and pixel sizes (FOV & matrix combinations) based on gradient specifications, thermal model of the gradient coil, specific absorption rate (SAR) models, dB/dt requirements and thermal model of the Advanced Control Gradient Driver (ACGD).

Zoom Mode

The Zoom gradient mode is used to optimize amplitude and slew rates over smaller regions of interest. The Zoom mode has a FOV of 40x40 cm in the X and Y planes and 35 cm in the Z direction. Therefore, body parts must be well positioned within the FOV of the coil when operating in Zoom mode.

Applications of the Zoom mode include:

- High end cardiac imaging
- Brain imaging
- Functional MRI (fMRI) studies
- High resolution orthopedic imaging

Due to its higher gradient amplitude and slew rate specifications, the Zoom mode is primarily used for imaging small FOVs with thin slices acquired with SE, FSE, and GRE pulse sequences. All advanced neurovascular and cardiovascular applications in Zoom mode primarily use EPI, Diffusion Weighted Imaging (DWI) EPI, Spiral, and Fast Gradient Echo (FGRE) pulse sequences.

Whole Body Mode

The Whole Body gradient mode is used to obtain the highest linearity and largest FOV (48 cm) operation. The Whole Body mode is used primarily for applications demanding large coverage along the magnet axis, or large off-center imaging (>20 cm off-center).

Applications of the Whole Body mode include:

- Spine (sagittal and coronal)
- Shoulder
- Coronal and sagittal abdomen
- Coronal and sagittal extremities

The Whole Body mode is primarily used for conventional Magnetic Resonance Imaging (MRI) sequences; Spin Echo (SE), Fast Spin Echo (FSE), Gradient Echo (GRE), and multi-shot Echo Planar Imaging (EPI).

Prescribing Images

3-Plane graphic prescription (GRx) allows you to define slices and saturation (SAT) bands while visualizing their exact locations on three different image planes simultaneously. This feature helps you achieve reductions in prescription time, as well as increase your prescription accuracy.

Refer to the Prescribing Images chapter in this guide for additional information.

Imaging Parameters

For improved imaging flexibility, existing options such as ZIP 512, Magnetization Transfer, Variable Frequency Matrix and the Oblique scan plane are now compatible with additional pulse sequences. Table 2-1 demonstrates the compatibility between these parameters and the additional pulse sequences they can be used with.

Table 2-1 Imaging Parameter Compatibility Chart

Imaging Parameters	Pulse Sequences		
	Spin Echo	2D GRE	3D GRE
Oblique Scan Plane	Yes	Yes	Yes
Variable Frequency Matrix	Yes	Yes	Yes
ZIP 512	Yes	Yes	Yes
Magnetization Transfer	Yes	Yes	Yes

Fast Spin Echo Pulse Sequences

The following pulse sequences are new or contain enhancements.

- Three Dimensional Fast Spin Echo (3D FSE)
- Fluid Attenuated Inversion Recovery (FLAIR)
- T1 Fluid Attenuated Inversion Recovery (T1 FLAIR)
- Single Shot Fast Spin Echo (SSFSE)
- Single Shot Fast Spin Echo - Magnetic Resonance Cholangiopancreatography (SSFSE-MRCP)

Refer to the Fast Spin Echo Pulse Sequences chapter in this guide for additional information.

Echo Planar Imaging Pulse Sequences

Increased gradient strength enables Diffusion Echo Planar Imaging (Diff EPI) sensitivities to extend beyond the standard B-value of 1000 s/mm². The maximum B-value is now 7000 s/mm². This allows greater diffusion weighting, increasing the sensitivity of detection of non-mobile protons.

3D FIESTA Pulse Sequence

The Fast Imaging Employing STeady-state Acquisition (FIESTA) is a fully balanced steady-state coherent imaging pulse sequence designed to produce high signal-to-noise (SNR) images at very short sequence times (TR). This guide provides you with information on the pulsing components and timing factors directly related to the 3D FIESTA imaging pulse sequence.

Refer to the 3D FIESTA Pulse Sequences chapter in this guide for additional information.

Clinical Spectroscopy Pulse Sequences

Prostate Spectroscopy Imaging Exam (PROSE) is a new 3D clinical spectroscopy sequence designed for producing spectra of the prostate area. PROSE produces multiple chemical shift spectra allowing you to examine the compounds present in the prostate area.

Refer to the Clinical Spectroscopy Pulse Sequences chapter in this guide for additional information.

2D FIESTA Pulse Sequence

The Fast Imaging Employing STeady-state Acquisition (FIESTA) is a fully balanced steady-state coherent imaging pulse sequence designed to produce high signal-to-noise (SNR) images at very short sequence times (TR). This guide provides you with information on the pulsing components and timing factors directly related to the 2D FIESTA imaging pulse sequence.

Refer to the 2D FIESTA Pulse Sequences chapter in this guide for additional information.

Myocardial Assessment Pulse Sequences

Myocardial Assessment is an imaging technique used to evaluate myocardial viability. The technique consists of a three sequence protocol used to demonstrate heart function, myocardial perfusion, and overall viability of the myocardium. This guide explains the background of the Myocardial Assessment protocol and the sequences used in imaging myocardial assessment.

Refer to the Myocardial Assessment Pulse Sequences chapter in this guide for additional information.

FGRET Pulse Sequences

Fast Gradient Echo-Echo Train (FGRET) is a Fast Gradient Echo (FGRE) sequence with an echo-planar (EPI) readout. Features of both the FGRE and EPI pulse sequences are combined for use in cardiac applications. This guide explains the pulsing components and timing factors directly related to the FGRET imaging pulse sequence.

Refer to the FGRET Pulse Sequences chapter in this guide for additional information.

Spiral Pulse Sequences

The Spiral pulse sequence is a 2D, Gradient Echo (GRE) or SPOiled Gradient Echo (SPGR) sequence which uses a spiral K-space trajectory to obtain the required data for image creation. This guide explains the pulsing components and timing factors directly related to the Spiral imaging pulse sequences.

Refer to the Spiral Pulse Sequences chapter in this guide for additional information.

Imaging Options

There are four new features on the Imaging Options window.

- T2 Prep
- Spectral Spatial RF
- Fluoro Trigger
- Phase Sensitive

T2 Prep

T2 Prep is an option available with Spiral imaging. It can be used to suppress tissue and decrease signal from various structures.

Refer to the Spiral Pulse Sequences chapter in this for information on T2 Prep.

Spectral Spatial RF

Spectral Spatial RF (SSRF) is an imaging option used to suppress signal from fat during Spiral sequences and suppresses fat and water when used with PROSE pulse sequences.

Refer to the Spiral Pulse Sequences and Clinical Spectroscopy Pulse Sequences chapters in this guide for information on SSRF.

Fluoro Trigger

Fluoro Trigger is an option available with Fluoroscopic Triggered Magnetic Resonance Angiography (FT MRA) imaging. It must be used in order to perform a FT MRA sequence.

Refer to the Bolus Triggering chapter in this guide for information on Fluoro Trigger.

Bolus Triggering

Fluoroscopic Triggered Magnetic Resonance Angiography (FT MRA) is a technique that uses a thick slab, two-dimensional (2D) real time acquisition and reconstruction to monitor the region of interest for contrast bolus.

Refer to the Bolus Triggering chapter in this guide for additional information.

Bolus Chasing

SmartStep has been improved to include:

- Capability of saving a site customized protocol,
- Automatic prescanning of all saved series,
- A quiet delay period after the bolus has been detected,
- A delay count-down timer after the bolus has been detected,
- Four K-space filling options, and
- Easier selection of mask and venous series.

Refer to the Bolus Chasing chapter in this guide for additional information.

Real Time Imaging

iDrive™ Pro Plus is an optional software package that provides you with a flexible environment for using real time imaging. This guide explains how to image real time with iDrive Pro Plus. It provides key concepts regarding the acquisition, tools, and image review options available.

Refer to the Real Time Imaging chapter in this guide for additional information.

Displaying Images

Several changes have occurred within the Reference Image Viewer feature. The following is a list of things you can do to a referenced image:

- Window/Level (all methods)
- Image selection buttons (Image +/-)
- Zoom
- Display Normal
- Flip/Rotate
- Pan

When you click the **[Image]** button on the Film Composer icon on the Film Composer Options window, both the Reference image and the Primary image appear within a film format cell. Note the size relationship between the Primary and the Reference images is not indicative of what the images will look like when the film is printed. The Reference image is larger than it appears on the film.

All Reference image viewports display the same image. You can no longer put unique images within separate or different viewports. If you change the image within one Reference image viewport, all other Reference image viewports update to the same image, even if you have isolated the Reference image viewport through a double-click.

If you have the Reference images displayed in all of the viewports and use the F4 (Film Series) feature, reference images will be printed. If a Reference image is not on all viewports, no reference images will be printed.

Functool

The PROSE sequence can be displayed through Functool, located on your Browser. PROSE sequences are displayed in the same manner 3D Focal Brain spectroscopy sequences are.

Refer to the Functool chapter in this guide for additional information.

ASSET

Array Spatial Sensitivity Encoding Technique (ASSET) is an imaging feature that allows faster scanning when using phased array coils. It is designed to achieve shorter breath-held acquisitions, thus making it easier for your patients experiencing difficulty holding their breath for long periods of time.

Refer to the Imaging with ASSET chapter in this guide for additional information.

Accelerator Commands

There are several changes in the naming conventions of the Accelerator Commands. Table 2-2 lists the updated Accelerator Commands along with their type-in abbreviation and description.

Table 2-2 Accelerator Commands

Command	Type-in Abbreviation	Description
Image Manipulation		
Flip horizontal	ftb	Flips the image horizontally (top to bottom).
Flip vertical	flr	Flips the image vertically (left to right).
Format	fo	Sets the display format to a maximum of five rows and five columns. For example, fo 3 5 .
Reset	rs	Resets the initial display parameters.
Zoom	zo	Sets the magnification factor. For example, zo 2 .
Invert	inv	Inverts the video.
Graphics		
Report cursor	rc	Creates a report cursor graphic.
Report pixel	rp	Displays a 4x4 mm cursor that can be dragged to a new location. When the cursor is deposited, the mean, standard deviation, and area are displayed.

Chapter 3

Prescribing Images

Introduction

3-Plane graphic prescription (GRx) allows you to define slices and saturation (SAT) bands while visualizing their exact locations on three different image planes simultaneously. This feature helps you achieve reductions in prescription time, as well as increase your prescription accuracy.

This chapter explains the process of prescribing images. It provides the concepts necessary to graphically prescribe image locations, the tracker location, and SAT bands, as well as the basic steps to apply these techniques. It contains the step-by-step instructions to help you learn how to:

- Prescribe 2D graphic locations
 - Single and multi-group locations
 - Radial locations
- Prescribe 3D graphic locations
 - Single and multi-slab locations
 - Tracker location
- Prescribe SAT locations

In addition, this chapter answers the following questions:

1. What are the advantages of 3-Plane GRx?
2. What scan planes can I prescribe in 3-Plane GRx?
3. What types of prescriptions can I prescribe in 3-Plane GRx?
4. What imaging mode allows me to prescribe a tracker?
5. How many SAT bands can I prescribe at one time?

What Do I Need to Know About...

This section presents the concepts necessary to successfully complete the process of prescribing images. Specifically, you need to understand:

- 3-Plane GRx Basics
 - Acquiring Valid Localizers
 - Defining the Scanning Range
 - Localizer Viewports
 - Selecting Images
- Two-dimensional Prescription
 - Multi-group Prescription
 - Radial Prescription
- Three-dimensional Prescription
 - Multi-slab Prescription
 - Tracker Prescription
- SAT prescription
- 3-Plane GRx functions
 - Report Cursor
 - Zoom
 - Display Normal
 - Window Width and Level
 - Pan
 - Reference Lines
 - Copy Rx
 - Reset Center

3-Plane GRx Basics

3-Plane GRx allows you to define slices and SAT bands while visualizing their exact locations on three different image planes simultaneously. This feature is facilitated by using one image (acquired from a 3-Plane or any localizer) from each plane in conjunction with another during graphic prescription. It allows you to graphically prescribe on any of the images from the localizing series. It also gives you the flexibility of manipulating slice location and placement on any one of the three images interactively, while observing the resultant changes in the prescription in the other two planes. 3-Plane GRx helps you achieve reductions in prescription time, as well as increase your prescription accuracy.

During 3-Plane GRx, you can:

- Use the List Select window to load localizer images into the viewports
- Create different slice groups (parallel, oblique, radial, 2D, 3D, Tracker, and SAT)
- Move, size, and rotate the prescription not only on the viewport in which you deposited the prescription, but also the other two viewports
- Increase or decrease the number of slices or slabs
- Operate on the different slice groups (edit, delete, rotate, or resize)
- View graphic slice locations and SAT bands together in all viewports
- View and edit some application parameters based on the prescription and pulse sequence you select
- Save a 3-Plane GRx prescription as protocol

3-Plane GRx is available with all scan planes, although the behavior it exhibits may differ depending on the scan plane prescribed. Table 3-1 lists the action taken by 3-Plane GRx with each scan plane.

Table 3-1 Scan Plane and 3-Plane GRx Behavior

Scan Plane	Action in 3-Plane GRx
Axial	Only axial slices shall be prescribed. No rotation is allowed.
Sagittal	Only sagittal slices shall be prescribed. No rotation is allowed.
Coronal	Only coronal slices shall be prescribed. No rotation is allowed.
Oblique	No restrictions on prescribed slices. Rotation is allowed in all intersections shown.

3-Plane GRx allows you to prescribe the following types of prescriptions:

- Two-dimensional (2D)
 - Radial
 - Multi-group
 - SAT
- Three-dimensional (3D)
 - Tracker
 - Multi-slab
 - SAT

The 3-Plane GRx can be manipulated in either the 2D or 3D GRx mode and also in the SAT mode. 3-Plane GRx is viewable and editable in the SAT mode, and the SAT bands are viewable and editable in the GRx mode. However, new SAT bands cannot be created on the GRx screen and new GRx groups cannot be deposited on the SAT screen.

The 3-Plane GRx and the Tracker prescription display together in the Tracker mode and you are able to manipulate the tracker as well as the GRx volume.

Upon completion of a 2D, 3D, or SAT prescription, the 3-Plane GRx data is translated into right, anterior, and superior (RAS) coordinates, these values are passed on to scan, and the geometry calculations are completed and updated.

Acquiring Valid Localizers

The **Graphic Rx** icon (Figure 3-1) is available in the Additional Parameters area when you are defining a series prescription.

Figure 3-1 Graphic Rx Icon



3-Plane GRx can be used after an axial, sagittal, coronal, oblique, or 3-Plane scan has been completed. A valid localizer has the same patient entry, patient position, and landmark as the current prescription. The valid localizers for 2D and 3D mode for each plane are given in Table 3-2.

Table 3-2 Valid Localizers for 2D and 3D Modes

Current Prescription Plane	Valid Localizer
Axial	Sagittal, Coronal
Sagittal	Axial, Coronal
Coronal	Axial, Sagittal
Oblique	Axial, Sagittal, Coronal, Oblique

Valid localizers for SAT prescriptions for each plane are given in Table 3-3.

Table 3-3 Valid Localizers for SAT Prescriptions

Current SAT Band	Valid Localizer
Axial	Sagittal, Coronal, Axial
Sagittal	Axial, Coronal, Sagittal
Coronal	Axial, Sagittal, Coronal
Oblique	Axial, Sagittal, Coronal, Oblique

Defining the Scanning Range

When defining the scanning range in 3-Plane GRx, there are some prescription limitations you need to consider. Table 3-4 provides you with the limitations of 3-Plane GRx prescriptions.

Table 3-4 Prescription Limitations

Prescription	Limitations
3-Plane GRx	A maximum of 256 slices can be prescribed.
3-Plane SAT	A maximum of 6 SAT bands can be prescribed.
3-Plane Tracker	A maximum of 1Tracker prescription can be deposited.

3-Plane GRx allows you to change the following Scanning Range parameters as per the mode selected in Table 3-5. The corresponding changes display in all three viewports.

Table 3-5 Editable Scanning Range Parameters

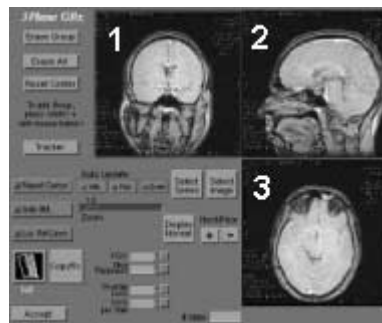
Mode	Scanning Range Parameters
2D	FOV, Spacing, Slice Thickness, Frequency Direction, and Phase FOV
3D	FOV, Slice Thickness, Overlap Locations, Number of Locations per Slab, and Phase FOV

The Scanning Range area updates after you accept the prescription. You cannot edit the parameters once a prescription is present and you close 3-Plane GRx. You are only able to see and modify the graphic prescription previously made by re-entering the **Graphic Rx** icon in the Additional Parameters area.

Localizer Viewports

When you open 3-Plane GRx, a busy cursor appears on the screen until initialization is complete and the appropriate three localizer images display. 3-Plane GRx has three 410x410 localizer viewports (Figure 3-2).

Figure 3-2 3-Plane GRx Viewports



The localizer images can be images from a 3-Plane Localizer or, if another series is used, three images of the same plane display. A prescription can be made on any of the three localizer images. The intersections of the slices prescribed are shown on the other viewports. For example, if a graphic prescription is made on the Viewport1 localizer image, the slice intersections are shown on Viewport2 and Viewport3 localizer images. The intersections signify the area on the localizer image that will be scanned.

There are various scenarios 3-Plane GRx uses for determining which localizer images are displayed as default images in the three viewports.

- If you are opening 3-Plane GRx for the first time, the middle image of the coronal set of the most recent series of the 3-Plane Localizer loads in the first viewport. The middle image of the sagittal set loads in Viewport2 and the middle image of the axial set loads in Viewport3.
 - If the localizer series is not a 3-Plane Localizer, the last compatible series scanned is divided into thirds and loads in the viewports, displaying the center slices of each third.
- If you are entering 3-Plane GRx for the second time and have acquired a 3-Plane Localizer, the system displays this series.
 - If this localizer series is not a 3-Plane Localizer, the valid localized series for the set prescription displays.
- If you had previously prescribed SAT bands, then the default images are the localizers that were used in the SAT prescription.

At any instant of time one of the three viewports is always highlighted. The active viewport is highlighted with a green or bright border. There are various graphic tools that can be applied either to a selected viewport or to all the viewports. The following tools operate on the images loaded into the viewports:

- Window and Level (W/L) – using the center mouse button
- Pan – using the right mouse button
- Zoom – using the slider
- Report cursor – using the toggle button

When communication with the Graphic server is lost and the system does not respond to any of your actions on the 3-Plane GRx screen for an amount of time, an error message posts (Figure 3-3) and the 3-Plane GRx window closes. You are able to re-enter 3-Plane GRx by clicking the **Graphic Rx** icon again, retaining all of your deposited prescriptions.

Figure 3-3 Communication Error Message Box

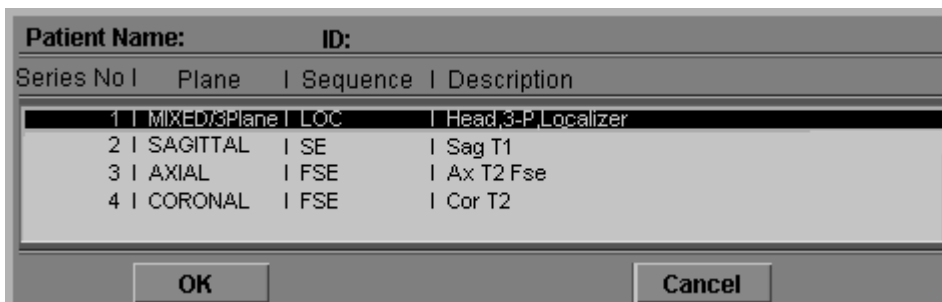


Selecting Images

The List Select window allows you to select a series other than the default localized series for the scan. When you click the **[Select Series]** or **[Select Image]** buttons (Figure 3-4), the List Select Series (Figure 3-5) or the List Select Image window opens in the bottom corner of the 3-Plane GRx screen.

Figure 3-4 Select Series and Image Buttons



Figure 3-5 List Select Series Window

The List Select window provides a filtered list of series that fit to the current patient, with same study and same location.

You can only select the same series for all viewports. Then you are able to select an individual viewport and put a specific image in that viewport from the selected series. Loading a specific localizer image on any of the three viewports can be accomplished by clicking the **[Select Series]** button to choose the desired series and the **[Select Image]** button to load the selected localizer image.

You are able to select any series from the list. For any series other than a 3-Plane Localizer, the middle image of the selected series loads in the second viewport and images on either end of the same series load in viewports one and three. For example, if there are 9 images in the currently selected series, then image 2, 5, and 8 are loaded in the viewports.

The select series button is disabled when there is a prescription on any of the viewports. When you click the **[Erase All]** button or when there are no prescriptions on the viewport, the **[Select Series]** button is enabled again.

The **[Select Image]** button displays all the images of the current series. The image shown in the currently highlighted viewport is highlighted in the list of images. You are able to select any image from the list and that image loads in the currently highlighted viewport.

You are also able to switch between images in a valid localizer image set using the **[+]** (Next) or **[-]** (Prior) buttons. The Next button moves to the next image of the currently selected series for the active viewport. The Prior button moves to the previous image of the currently selected series for the active viewport.

Two-dimensional Prescription

Upon clicking the **Graphic Rx** icon in a 2D prescription, the 3-Plane GRx screen opens and displays with the default images in the viewports (Figure 3-6).

Figure 3-6 3-Plane GRx Screen for a 2D Prescription



Table 3-6 provides a description and acceptable values for each selection on the 3-Plane GRx screen for 2D prescriptions.

Table 3-6 3-Plane GRx Selections and Descriptions for 2D Prescriptions

Selection	Description
[Erase Group]	Erases a particular group of slices or slabs and its corresponding intersections.
[Erase All]	Erases all the prescriptions and its intersections. Only enabled when there are prescriptions present.
[Reset Center]	Allows you to page through a data set and reselect a new center image for prescription. The new center is based on the image in the active viewport.
Instructions for Add Group	Adds a group of slices in a different location.
Report Cursor	Provides a report of the cursor location on each of the three viewports.

Selection	Description
Keep W/L	Keeps the selected W/L for the active viewport. The W/L remains at the Keep W/L values as the [+] and [-] buttons are used to view other images within the selected viewport. If Keep W/L is not on, then as the [+] and [-] buttons are used to view other images within the selected viewport, the W/L reverts to the auto W/L values.
Loc Ref Lines	Allows you to view the reference lines on all viewports. The lines represent the location of the other two graphic planes. For example, the lines on the sagittal localizer image represent the locations of the axial and coronal localizer images.
SAT icon	Opens the SAT screen. The currently prescribed slices are automatically accepted.
[Copy Rx]	Copies a previous Rx with the same FOV, slice thickness, and spacing. A single click on the desired series to copy followed by [Accept] displays the same slice locations on the currently displayed image. A double-click displays image used to prescribe slices for the copied series and the slice locations.
[Accept]	Registers slice prescription and exits Graphic Rx.
Viewport1	Displays the middle slice of the first half of the most recent series which could be used as a localizer. Displays the middle coronal image if a 3-Plane Localizer was acquired.
Viewport2	Displays the middle slice of the most recent series which could be used as a localizer. Displays the middle sagittal image if a 3-Plane Localizer was acquired.
Viewport3	Displays the middle slice of the last half of the most recent series which could be used as a localizer. Displays the middle axial image if a 3-Plane Localizer was acquired.
Auto Update: W/L	Enables the W/L function to apply on all viewports.
Auto Update: Pan	Enables the pan function to apply on all viewports.
Auto Update: Zoom	Enables the Zoom function to apply on all viewports.
Zoom	Adjusts magnification factor for displayed images using the slider.
[Select Series]	Lists valid series from which a localizer image can be selected.
[Select Image]	Lists the images for the selected series.

Selection	Description
[Display Normal]	Returns the displayed image to its default size and location. In other words, it removes the pan and zoom factors.
[-] [+] (Prior/Next)	Displays the previous or next image in the series from the currently displayed image.
Text Box	Allows you to enter the series and image number for the images you wish to display.
Phase FOV	Allows you to shorten the scan time by scaling down the FOV size in the phase direction. The pulse sequence determines the range and increment values.
Freq DIR	Defines the scanning direction associated with the frequency encoding gradient. In general, frequency is the long axis of the imaging plane. The default frequency direction is automatically entered, but you can swap frequency and phase directions by changing the entry from the predefined list.
FOV	Defines the area of the anatomy selected for imaging. The size is indicated in centimeters.
Slice Thickness	Assigns thickness of each slice location in millimeters.
Spacing	Assigns space between the slices.
# Slices	Reports the number of slices prescribed. A value is automatically entered in this text box if slice thickness, slice spacing, and the start and end locations are specified. You cannot manually enter a value.

The length of the Slice lines in a 2D graphic prescription represent the FOV coverage. The graphic objects on the Slice lines in 3-Plane GRx enable you to define where and how to acquire the slices.

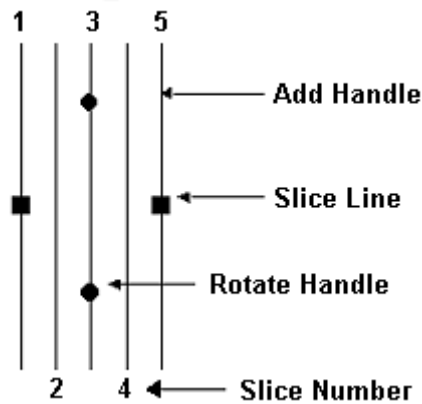
The graphic objects have handles for rotating, adding, or removing slices based on the prescription restrictions. You can move and rotate the prescription in progress not only in the viewport in which you deposited the locations, but also in the other two viewports.

The graphic objects provide the following functionality:

- The Add handle gives you the ability to increase or decrease the number of slices.
- The Rotate handles appear at the center of the slice group (one above and one below the center of the slice) for oblique prescriptions to give you the ability to turn the slice prescriptions.
- The Slice lines allow movement of the prescription by clicking and dragging on any area of the slice line other than the handles, to adjust the position of the entire graphic prescription.

The selected graphic objects in the active viewport appear blue and the unselected graphic objects appear yellow. The graphic objects of a 2D prescription are shown in Figure 3-7.

Figure 3-7 2D Graphic Objects



As you add or delete slices, the slice numbers appear or disappear accordingly.

NOTE: If your system has a black and white monitor, the graphic objects appear white and the active group displays the graphic handles.

Multi-group Prescription

It is possible to prescribe multiple groups of slices within one acquisition. This is useful when an entire range of slice locations is not desired or needed for a given anatomical body part (e.g., axial spine and sagittal TMJ examinations).

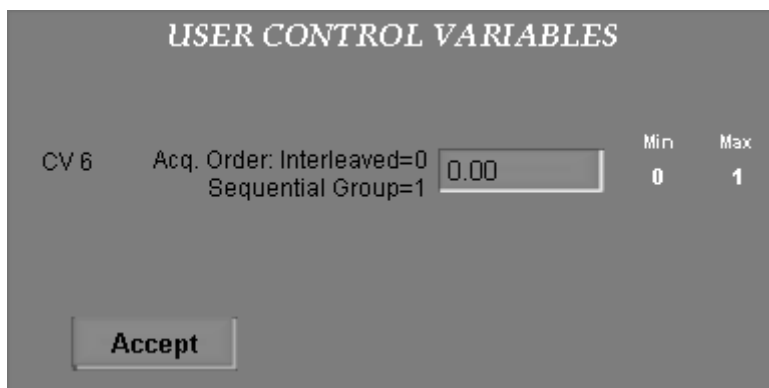
Multi-slice Multi-angle (MSMA) means all prescribed slices are acquired within a single acquisition and Multi-slice Multi-group (MSMG) means only the slices within an angled group are acquired within a single acquisition. Three angled groups of slices therefore results in three separate acquisitions.

MSMA is compatible with all pulse sequences. Note that, dark banding artifacts, commonly known as cross-talk, and low SNR tissue contrast changes are likely to occur when MSMA slices intersect. To avoid these cross-talk artifacts, do not intersect the slices within the anatomy of interest. Cross-talk artifacts are not seen with MSMG.

If using a Fast Spin Echo - Accelerated (FSE-XL), Fast Recovery Fast Spin Echo - Accelerated (FRFSE-XL), or a T1 Fluid Attenuated Inversion Recovery (FLAIR) pulse sequence, a user control variable (CV) becomes

available with the prescription, allowing you to choose between MSMA and MSMG. Figure 3-8 illustrates the acquisition order options of choosing an interleaved or a sequential group for the current acquisition.

Figure 3-8 User CVs Screen for a Multi-group Prescription



You must define the acquisition order by selecting an Interleaved Acquisition or a Sequential Group. Selecting Sequential Group (1) results in a MSMA acquisition and selecting Interleaved (0) results in a MSMG acquisition.

With MSMA and MSMG prescriptions, the color for the selected group and its corresponding intersections is blue and a yellow color represents the unselected group and its corresponding intersections. The intersections display on all the three viewports for all the groups present.

When prescribing MSMA or MSMG acquisitions, the group with the largest number of slices controls the frequency and phase direction. For example, if you are prescribing axial slices through the disc spaces on a Lumbar (L) spine examination, you may prescribe three slices through L3-4 and L4-5 that have a small angle. Then you may prescribe five, very steep angled slices through the L5-S1 disc space. The steep angle, passing 45°, makes the slices an obliques-coronal and the frequency direction changes to S/I.

You may only perform the move, rotate, or add slices operations on one group at a time. Any changes within a group reflect in the corresponding displayed intersections. One group is always in the selected state. You are able to erase a single group after selecting the group and clicking the **[Erase Group]** button.

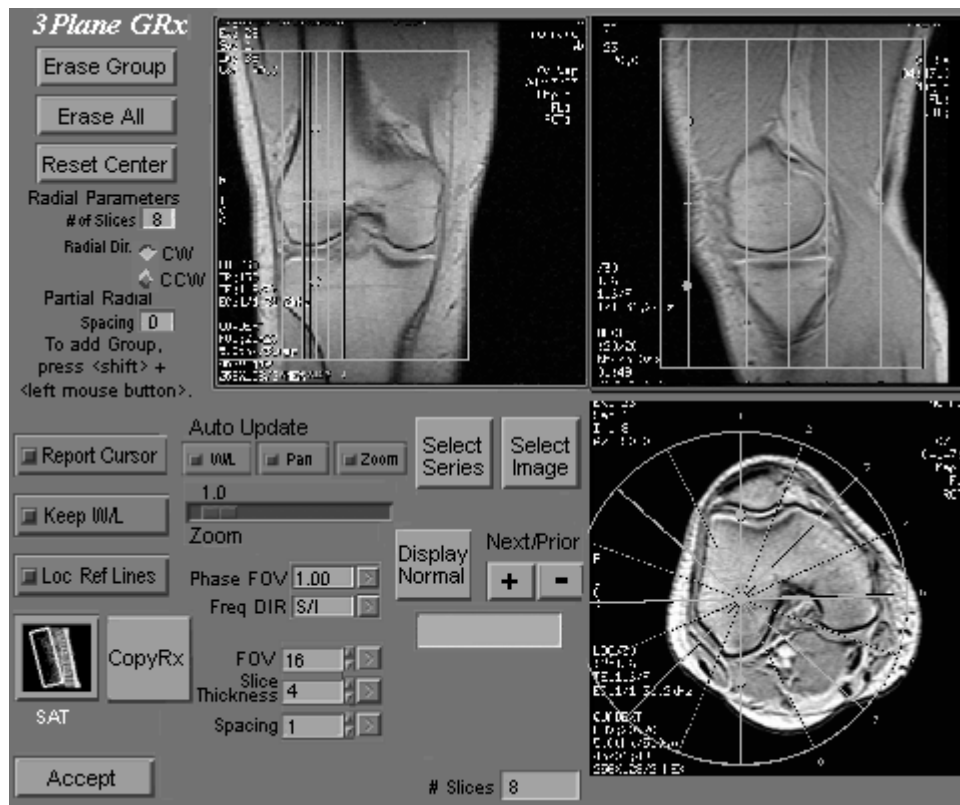
As you add or delete the slices in a multi-group prescription, the slice numbers appear or disappear accordingly with the slices shown. The numbers are contiguous across multiple groups.

Radial Prescription

Radial prescriptions can be prescribed graphically with 3-Plane GRx. This allows multiple slices to be acquired around a central axis in the same series. Radial and partial radial graphic prescription is available with FSE-XL, FRFSE-XL, Single Shot Fast Spin Echo (SSFSE), SSFSE-Inversion Recovery (IR), FastCard, FastCINE, and 2D FIESTA pulse sequences. This type of prescription can be useful for imaging, but not limited to, knees, Magnetic Resonance Cholangiopancreatographies (MRCPs), myelograms, and hearts.

When you are prescribing a radial sequence with 3-Plane GRx the GRx screen appears with several additional selections, as seen in Figure 3-9.

Figure 3-9 3-Plane GRx Screen for Radial Prescription



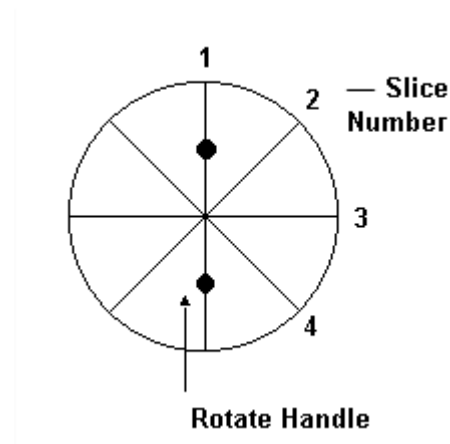
There are several additional selections on the 3-Plane GRx screen for a radial prescription defined in Table 3-7.

Table 3-7 3-Plane GRx Selections and Descriptions for Radial Prescription

Selection	Description
# of Slices	The number of slices prescribed for a radial graphic prescription. The maximum allowable is 36. Keep the number of slices at the default of one if you do not desire to perform a radial prescription.
Radial Dir.	Clockwise and counter clockwise directions for radial prescription. System defaults to clockwise.
Spacing	Controls the angle between slice locations by defining the degree of space between each slice.

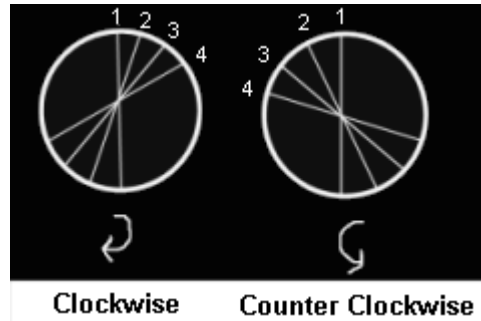
For radial prescriptions, you must define the number of slices and the radial direction while prescribing the acquisition. You have to explicitly type the number of slices in the **# of Slices** text box. The intersections accordingly display the number of slices in the three viewports. You can enter a different number of slices to dynamically change an active prescription.

The radial prescription has Rotate handles to turn the prescription and the slice numbers are displayed as in Figure 3-10. You are also able to move and rotate the intersections of the radial prescriptions. The intersections of the radial prescriptions display as blue bounding boxes (Figure 3-9).

Figure 3-10 Radial Graphic Objects

The radial direction can be clockwise or counterclockwise as shown in Figure 3-11. The system defaults to one slice and clockwise rotation. These settings can be changed.

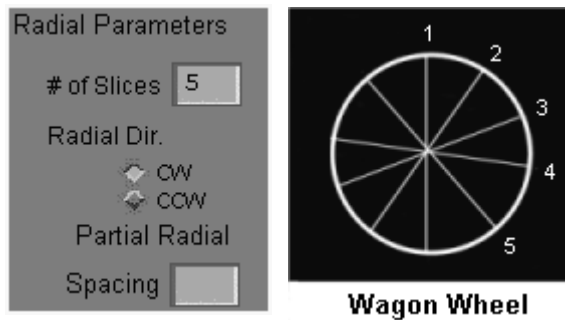
Figure 3-11 Radial Directions



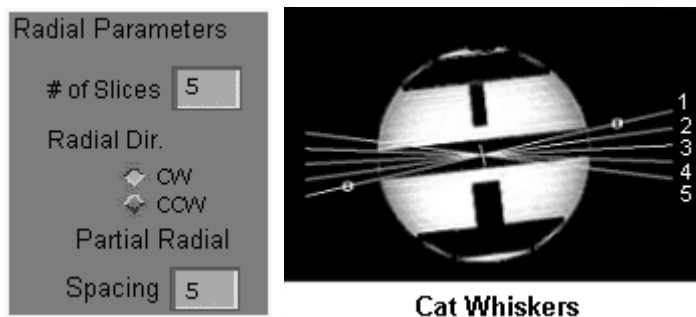
The maximum number of slices in a single group is determined by the selected pulse sequence. The largest number of slices that can be prescribed per group is 36 locations. If this limit is exceeded, the system will not accept the value. To continue, you must enter a new value with a lower number of slices.

The **# of Slices** and **Spacing** text boxes control the angle between the slices of the radial prescription. For example, if you select 5 slices in the Radial Parameters area and leave the **Partial Radial Spacing** text box empty, your graphic prescription looks like a wagon wheel with a 36° angle between each slice (Figure 3-12).

Figure 3-12 Wagon Wheel Radial Prescription



If you select 5 slices in the Radial Parameters area and 5° of spacing in the Partial Radial area, your graphic prescription looks more like cat whiskers (Figure 3-13) and there are 5° between each slice location.

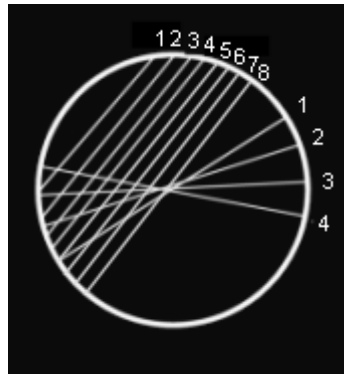
Figure 3-13 Cat Whiskers Radial Prescription

You may also prescribe multiple radial groups. Once you have deposited the first graphic prescription group, enter the desired value in the **# of Slices** text box in the Radial Parameters area for the second group and press **Enter**. The new, active radial graphic is deposited. It displays blue and the inactive, first group turns yellow.

If you are prescribing a FSE-XL radial sequence and the slice ordering is interleaved (acquires the maximum number of slices per acquisition,) your images may exhibit cross-talk and you do not have the option of choosing the number of locations before pause. Selecting Sequential slice ordering on the User CVs screen changes the number of slices to equal the number of acquisitions with no slice cross-talk.

After accepting a graphic prescription, you need to enter the number of locations before pause in the Acquisition Timing area. The number of locations before pause can be of a confusing nature. If you select zero, you do not have to push the scan button for every slice (angle), but you may have cross talk problems. If you select one, you control the scan, so you could let the tissue relax by waiting a few seconds before pressing the scan button.

Since each slice is an angle and each angle is a group, the maximum number of locations before pause is always one unless you prescribe an oblique group on the same series. For example, if you prescribe a radial scan with 4 slices and an oblique group with 8 slices, you could enter 8 in the **# of Locs Before Pause** text box. You would start the scan, the system would acquire those 8 slices, then you would hit scan four more times (one for each slice) to acquire the radial. The oblique slices in the group (single angle) would let you select 4 (or whatever number of locations before pause). See the example in Figure 3-14.

Figure 3-14 Multi-group Oblique and Radial Prescription

In addition, there are several factors you should consider when setting the locations before pause in radial prescriptions:

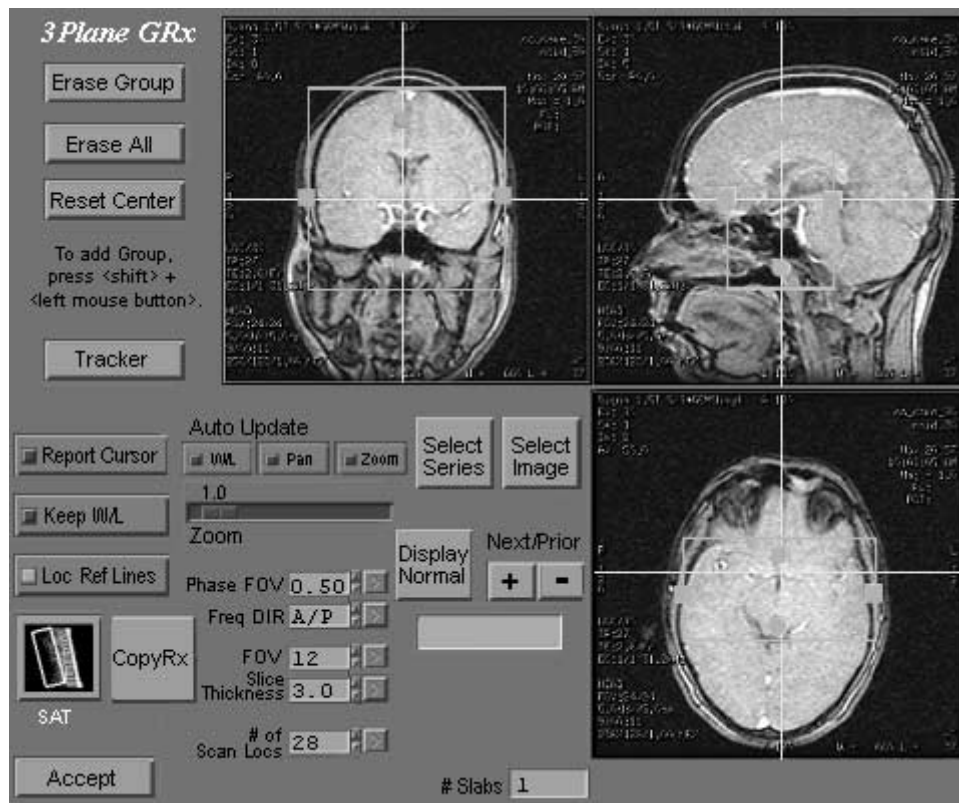
- Set the number of locations before pause to zero if all slices are the same angle. This allows you to scan all slices in one breath hold. For multiple shorter breath holds, type in any number to break up the group.
- Set the number of locations before pause to zero or one for a radial prescription. If you select one, the system pauses after each slice and you need to click the **[Scan]** button for each slice. Although zero is compatible, it causes cross-talk where the slices intersect.
- Set the locations before pause to the number of slices of the largest group when using MSMA. This enables you to scan one group or one angle at a time.

Three-dimensional Prescription

3-Plane GRx is also available in a 3D mode, as shown in Figure 3-15. The 3D mode excites an entire scan volume or slab with a wide RF pulse. Images acquired in 3D mode are spatially encoded in the phase, frequency, and slice axes.

Note the Localized Reference Lines (yellow or bright) are turned on in the 3D prescription in Figure 3-15. This is not automatic, you must click the **[Loc Ref Lines]** button to enable the feature.

Figure 3-15 3-Plane GRx Screen for 3D Prescriptions



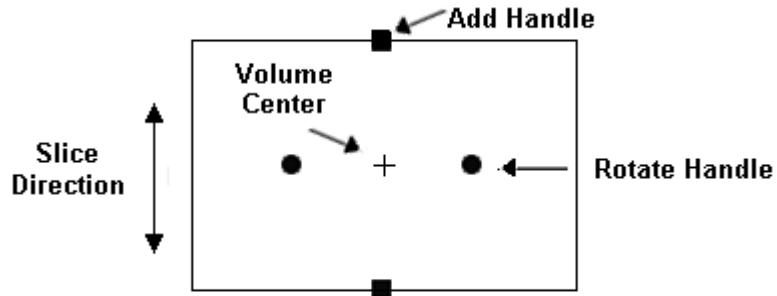
In addition to most of the selections on the 2D 3-Plane GRx screen, the following selections in Figure 3-8 are available on the 3-Plane GRx screen for 3D prescriptions.

Table 3-8 3-Plane GRx Selections and Descriptions for 3D Prescriptions

Selection	Description
[Tracker]	Defines the tracker slice location and thickness in a SmartPrep™ acquisition. (Only available with 3D Gradient Echo (GRE), Spoiled Gradient Echo (SPGR) or Time of Flight (TOF) pulse sequences.
# of Scan Locs	Defines the number of scan locations to be acquired in a single slab prescription.
Overlap Locs	Assigns the number of overlap locations (slices) per slab in a multi-slab prescription. (Only available with 3D GRE, SPGR, and TOF.
Locs per Slab	Defines the number of locations to be acquired per slab in multi-slab prescriptions.
# Slabs	Reports the number of slabs prescribed for a multi-slab acquisition.

In 3D prescription, the box displayed (Figure 3-16) represents the size of the imaging volume based on FOV, slice thickness, and number of scan locations selected in the scanning range. A selected 3D graphic object in the active viewport appears blue, while the unselected graphic objects appear yellow.

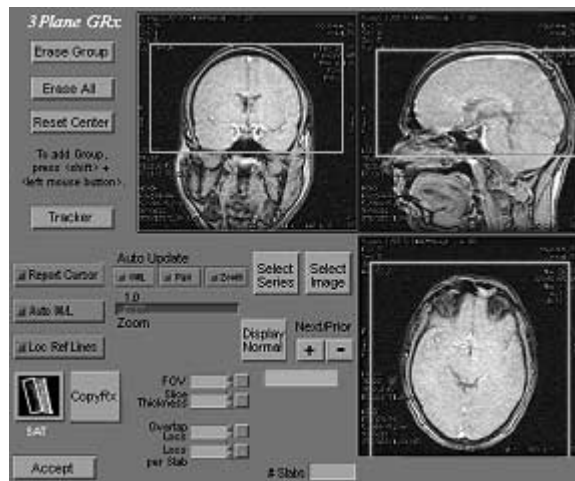
Figure 3-16 3D Graphic Objects



Oblique 3D has the same operation on the graphic slabs as in the 2D oblique mode. The Rotate handle and Add handle for slice prescription are available along with a tic mark indicating the center of the volume.

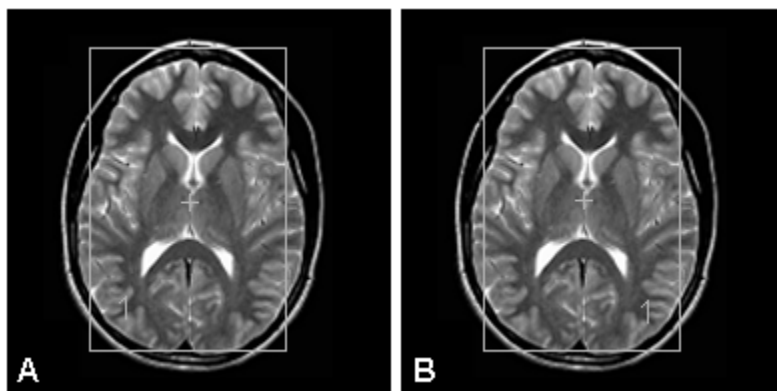
When the slice range extends to the center of the reference line, the FOV size is displayed on the localizer scan plane that is the same as the prescribed plane. The graphic box can be picked up by the edges and moved. This is a useful tool to verify the anatomy is not outside the phase FOV and if it is, then you can move the FOV accordingly. Figure 3-17 is an example of a 3D axial prescription. Note the FOV box displayed on the axial image. The box does not appear for 2D oblique prescriptions.

Figure 3-17 3D Axial Prescription



The 3D slice direction is displayed by the “1” and “+” which are displayed in the volume. The side to which the “1” is closest is the side of the volume that begins with the slice one.

Figure 3-18 Slice Ordering



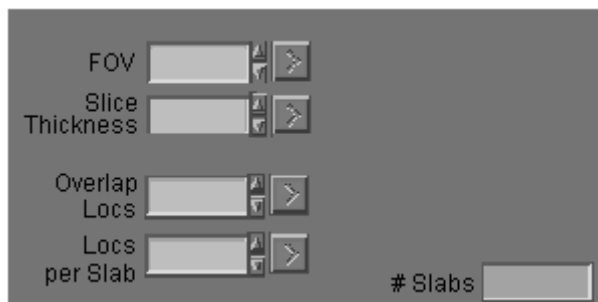
Prescription A displays the “1” to the left of the “+” indicating the images will be acquired left to right. Prescription B displays the “1” to the right of the “+” indicating the images will be acquired right to left.

Multi-slab Prescription

3D Multi-slab acquires multiple, overlapping image volumes, and combines overlapping locations from two adjacent slabs. The active slab and its intersections appear blue and an unselected slab appears yellow, along with its corresponding intersections.

The multi-slab editable text boxes in 3D 3-Plane GRx are shown in Figure 3-19.

Figure 3-19 3D Multi-slab Text Boxes

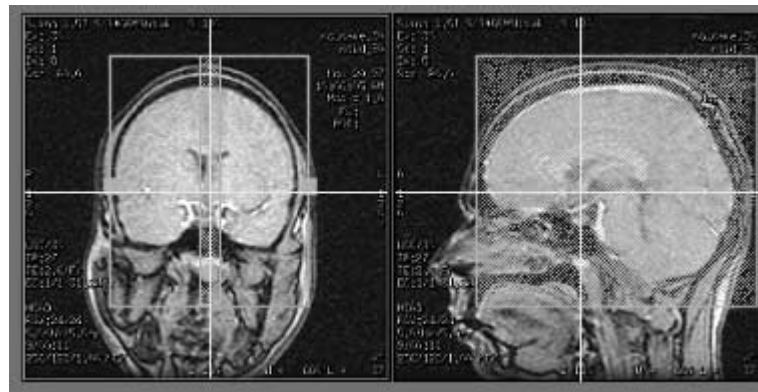


The purpose of the overlap is to have a prescription of slabs with overlaps that result in a continuous series of slices — with no gaps. Remember, any 3D acquisition has aliased image data on both ends of the slab, which is discarded. If this aliased (and discarded) image data is in the overlap area, the scan prescription should result in a continuous — no gap, set of slices.

With 3D multi-slab TOF acquisitions, if no overlap is prescribed between adjacent slabs, a substantial inter-slab boundary artifact (venetian blind) is created due to the decrease in blood-background signal to noise. An overlap of 25% is recommended, with uniform flip angle excitations, to minimize the artifact.

When the overlap locations are positioned over the center reference line, the slices perpendicular to the prescribed plane display the graphic volume with a grid like appearance (Figure 3-20).

Figure 3-20 3D Multi-slab Overlap

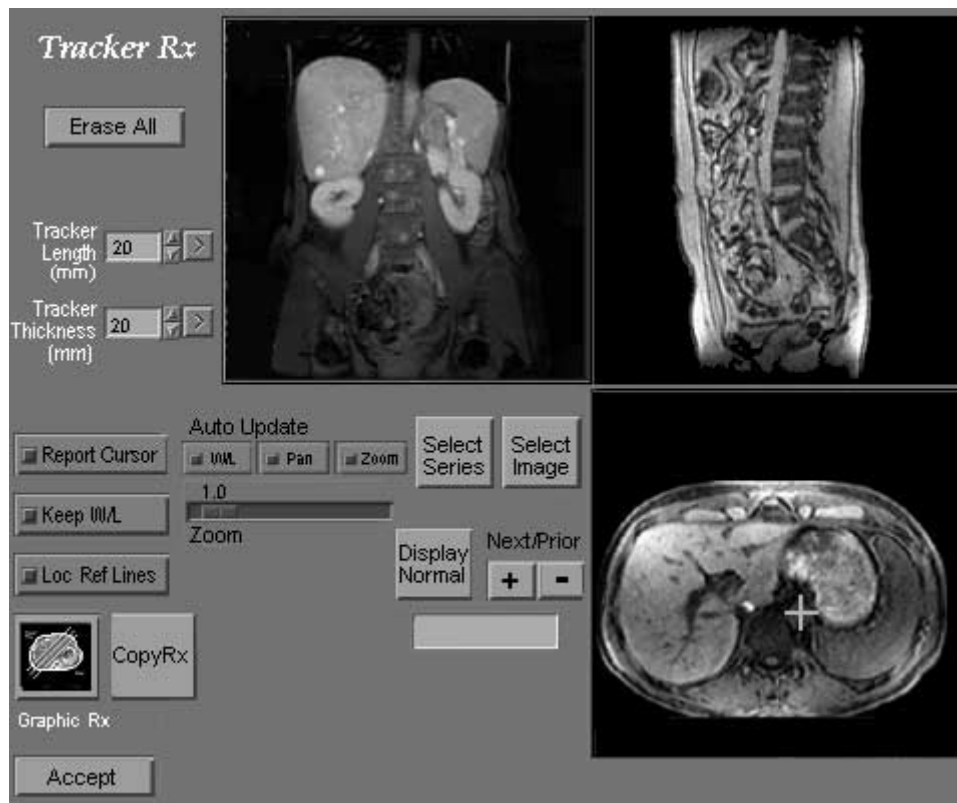


The shading in Figure 3-20 is to help you visualize anatomy that is overlapped on a multi-slab prescription. Note the grid like appearance of the slab on the sagittal image. This is due to the overlap area being placed over the sagittal reference line on the coronal localizer image. If you move the overlap area away from the sagittal reference line and the slab on the sagittal loses the grid like appearance.

Tracker Prescription

In 3-Plane GRx, you are able to deposit a Tracker prescription only for 3D Fast TOF pulse sequences. The Tracker Rx screen (Figure 3-21) is accessed by clicking the **[Tracker]** button on the 3D 3-Plane GRx screen. You are only able to view and manipulate the tracker in the viewport within which you initially deposit it.

Figure 3-21 3-Plane GRx Screen for a Tracker Prescription



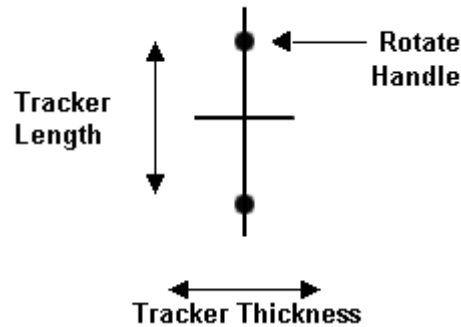
In addition to several of the selections available on the 3D 3-Plane GRx screen, Table 3-9 lists the other selections and their descriptions that become available when prescribing your tracker volume.

Table 3-9 3-Plane GRx Selections and Descriptions for Tracker Prescription

Selection	Description
Tracker Length (mm)	Defines the length of the tracker in millimeters.
Tracker Thickness (mm)	Defines the thickness of the tracker in millimeters.
[Accept]	Accepts the Tracker prescription and brings you back to the 3-Plane GRx screen.

The Tracker prescription, as shown in Figure 3-22, has two Rotate handles. One handle is above the prescription and one is below the prescription. The middle cross hair represents the thickness of the tracker and the length is represented by the size of the line.

Figure 3-22 Tracker Graphic Objects



You can use the Rotate handles to turn the Tracker prescription to angle with your vessel of interest. You can move the location of the Tracker prescription by clicking the prescription and dragging it.

The length of the Tracker prescription can be adjusted by entering a value in the **Tracker Length (mm)** text box in millimeters or by selecting the value from the drop down list provided. You can also change the thickness of the Tracker prescription by entering a value or selecting the value from the drop down list in the **Tracker Thickness (mm)** text box.

SAT Prescriptions

You can graphically prescribe SAT pulses on a localizer image from a valid series within the current exam. A valid series is any prospective orthogonal or oblique series with the same landmark.

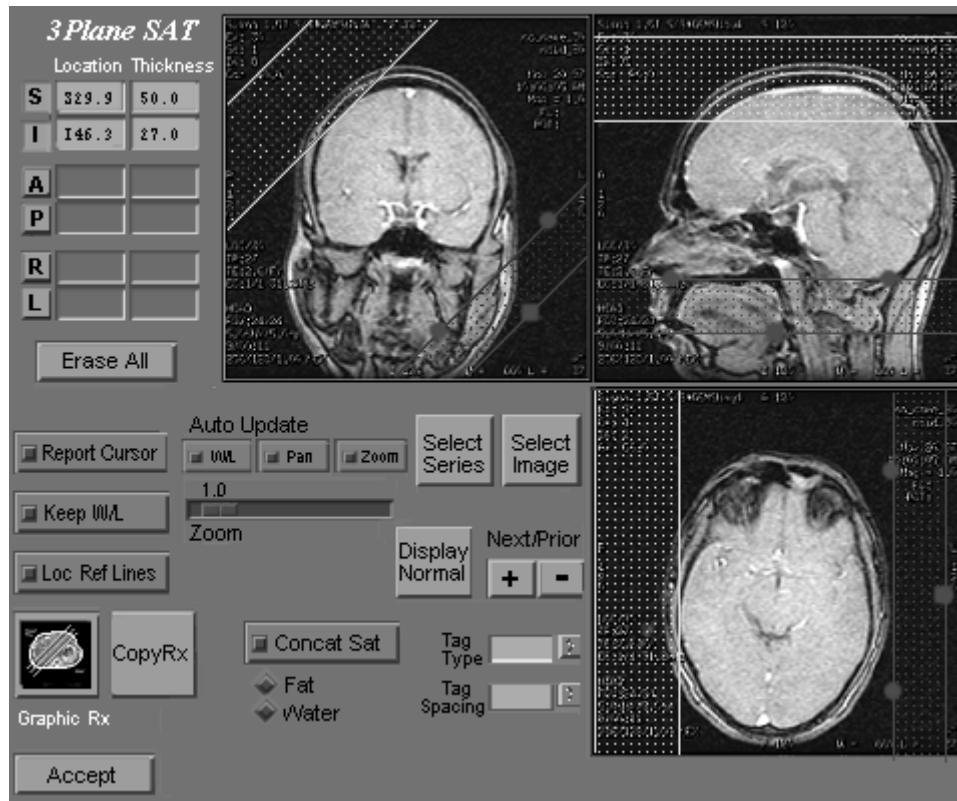
The SAT icon in the Additional Parameters area (Figure 3-23) becomes available after you acquire a valid series and if the series you are prescribing supports SAT bands.

Figure 3-23 SAT Additional Parameter



Upon clicking the **SAT** icon, the 3-Plane SAT screen (Figure 3-24) opens and displays with the default images in the viewports. Alternatively, you can access the SAT mode by clicking the **SAT** icon on the 3-Plane GRx screen.

Figure 3-24 3-Plane SAT Screen



In addition to the selections on the 3-Plane GRx screen, Table 3-10 provides you with the selections that become available on the 3-Plane SAT screen.

Table 3-10 Selections Unique to the 3-Plane SAT Screen and Descriptions

Selection	Description
S, I, A, P, L, R	Defines a SAT pulse in the direction of the selected plane.
Location	Defines the location of the leading edge of the SAT pulse. Leave this text box blank for default positioning of SAT outside FOV or adjacent to the first or last slice. A positive or negative numerical value is entered here to explicitly prescribe the SAT location.
Thickness	Defines the thickness/width of the SAT band. The default thickness is defined by the PSD and in most cases is 80 mm. Enter a value from 10 to 200 in steps of 1.
Graphic Rx icon	Opens the 3-Plane GRx screen. The currently prescribed saturation bands are automatically accepted.

Selection	Description
[Copy Rx]	Copies SAT prescriptions for a previously prescribed series to current series. All SAT selections must be deselected to use copy Rx. Select the desired series and click the [Accept] button or double-click the series. The SAT bands copy to and appear on the currently displayed images.
[Concat SAT]	Enables "walking SAT" for slice-select direction SAT pulses in concatenated acquisitions. Only valid with orthogonal images, parallel slices, and multi-acquisitions.
Fat	Suppresses fat using spectral or chemical saturation pulses. Center Frequency must be set to Water.
Water	To suppress water using spectral or chemical saturation pulses. Center Frequency must be set to FAT.
Tag Type	Allows selection of stripe or grid spatial SAT tags to obtain cardiac images sensitive to tissue motion. Only available with FastCINE and FastCard GRE pulse sequences.
Tag Spacing	Sets the distance of pixel spacing between the tag bands.
[Accept]	Registers SAT prescription and exits 3-Plane SAT.

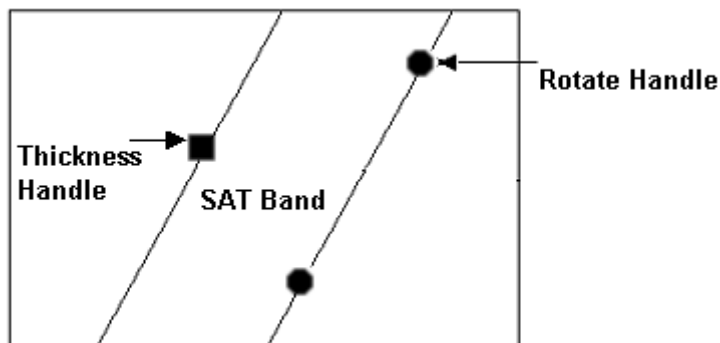
Clicking the directional buttons (S, I, A, P, R, L) allow you to prescribe SAT bands on any of the 3 localizer images. You are able to drop up to six SAT bands at one time. The intersections of the SAT bands display on the other 2 viewports.

The SAT bands display as rectangular dotted areas representing thickness and location. The SAT localizer images can be changed to prescribe SAT bands on various planes. You are able to move, size, and rotate the SAT bands on all the three viewports. A selected SAT band appears red and an unselected SAT band is yellow.

NOTE: If your system has a black and white monitor, the SAT bands appear white and the active band displays the handles.

There are two Rotate handles on the leading edge of the SAT band, one on each side of the center of the SAT band. A Thickness handle for changing the width of the band is also provided. You can change the bands location by clicking anywhere on it, except for the handles, and dragging it. These objects are shown in Figure 3-25.

Figure 3-25 SAT Objects



Not all six SAT bands are visible on one viewport. Table 3-11 provides the SAT bands you can see on the different planes of localized images.

Table 3-11 Visible SAT Bands for Localizers

SAT Bands	Localizer Plane
A, P, R, L	Axial
S, I, A, P	Sagittal
S, I, R, L	Coronal
S, I, A, P, R, L	Oblique

You are able to drop all six bands on different localizers based on the validity of the SAT bands for that localizer. For example, you may drop S and I bands on the sagittal localizer, A and P bands on the axial localizer, and R and L bands on the coronal localizer. The intersections for all of the bands display on the other viewports.

Once you deposit the band, you cannot drop the same type of band again in any of the other viewports. For example, if you drop an S band on the sagittal localizer, you cannot drop an S band again in any of the other localizers.

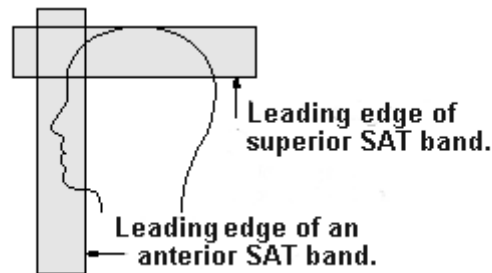
You can change the thickness of any band you deposit by dragging the Thickness handle provided on the SAT band or by explicitly typing the thickness value in the **Thickness** text box provided in the SAT screen. The change in the thickness of one SAT band changes the thickness in its corresponding intersections also.

The SAT pulse default location and thickness value change based on the pulse sequence selected. Generally, the thickness for Spatial SAT pulses default to 80 mm in all directions if a complimentary band does not currently exist. A complimentary band is a band opposite the selected band. For example, and inferior SAT band is complimentary to a superior SAT band. If

a complimentary band exists, then the thickness of the band equals the thickness of the complimentary pair band. Default location for Spatial SAT pulses are 30 mm away from the last slice, abutting the FOV in phase and frequency directions.

SAT bands may be prescribed inside or outside the scanning volume. SAT locations entered state the leading edge of the SAT pulse as shown in Figure 3-26.

Figure 3-26 SAT Band Leading Edges



The **SAT** icon, located in the Additional Parameters area, updates after you accept the prescription. It indicates the SAT pulses applied within the current series. For example, Figure 3-27 indicates the series prescription includes fat SAT, as well as an S and I SAT band.

Figure 3-27 SAT Icon with Applied Pulses



The icon only indicates if SAT has been turned on at its default value or if the SAT pulse location/thickness has been altered. It does not indicate the actual thickness or location. To view the thickness and location of SAT pulses, enter the SAT screen. Several examples of the **SAT** icon labels are listed below.

- Spatial SAT pulses applied at the default location and thickness are shown in upper case letters beneath the **SAT** icon, e.g., S, I.
- Spatial SAT pulses applied with a change to their thickness or location are shown in lower case letters, e.g., s, i.
- If Fat or Water suppression has been selected, the selection is indicated as FAT or WATER.
- If no SAT selections are made, the icon label reads, "SAT".

Disabling the direction button (S, I, A, P, R, L) deletes the corresponding band and its intersections from all the viewports. For example, if you click the **[S]** direction button and then click the sagittal localizer, an S band copies to the sagittal and coronal localizers. If you again click the **[S]** direction button (disabling), the S band that was copied to the sagittal and coronal localizers erases.

3-Plane Graphic Functions

There are various graphic functions that can be performed on a selected viewport or all three of the viewports. You can individually selected a viewport by clicking in that viewport. When a viewport is individually selected, it has a green colored or bright border.

Report Cursor

A report of the location of the cursor can be defined by selecting the **[Report Cursor]** button. The button toggles the location report on and off. When on, a yellow crosshair cursor is reported on all localizer images and the RAS coordinates are displayed in red at the bottom-right corner of each viewport. You are able to modify the prescriptions even in the presence of the Report Cursor.

Zoom

You are able to zoom all the three localizer images with the Zoom slider (Figure 3-28). The range of zoom factor is from 0.5 to 8.0. The images default at a zoom factor of 1.0, i.e., no zoom.

Figure 3-28 Zoom Slider



Zoom applies for all the three localizer images with the Auto Update **[Zoom]** button (Figure 3-29) enabled. If the Auto Update **[Zoom]** button is disabled, the zoom applies only to the currently selected image.

Figure 3-29 Auto Update Area



The zoom option functions with or without prescriptions in the viewport. You are able to page through the image sets either by clicking the **[+]** and **[-]** buttons or by selecting an image and the previous Zoom value will be retained. Clicking the **[Display Normal]** button removes the zoom factor.

Display Normal

The **[Display Normal]** button brings the zoomed image to a default zoom factor of 1.0, removes the pan factor, and displays the default W/L settings. This action applies to all the three viewports if Auto Update **[Zoom]** button is enabled.

Window Width and Level

Turning on the Keep W/L feature, keeps the selected W/L for the active viewport. The W/L remains at the Keep W/L values as you click the **[+]** and **[-]** buttons to view other images within the selected viewport. If Keep W/L is not on, then as you click the **[+]** and **[-]** buttons to view other images within the selected viewport, the W/L reverts to the auto W/L values.

You are also able to change the window width and window level on Viewports 1, 2, and 3 by middle-clicking and dragging on the image. The change in window width and level applies on all the 3 localizer images if the Auto Update **[W/L]** button is enabled. During window leveling, the cursor appears as a windowing cursor.

If the Auto Update **[W/L]** button is disabled, then the window leveling applies only on the image on which the action is being done.

Pan

You are able to move (pan the image) using the right mouse button. The panning action applies on all the three viewports if the Auto Update **[Pan]** button is enabled. If the Auto Update **[Pan]** button is disabled, then the movement applies only on the image on which the action is being done. You are able to page through the image sets either by clicking the **[+]** and **[-]** buttons or by selecting an image and the previous Pan value will be retained. Clicking the **[Display Normal]** button removes the pan factor.

Reference Lines

Reference Lines are displayed on all of the viewports based on the intersections made by that localizer image with the other two localizer images by enabling the **[Loc Ref Lines]** button. The localized reference lines appear as a yellow color line, exactly at the localizers' intersection. You are not be able to make any operations, such as moving or rotating the localized reference lines.

Copy Rx

Copy Rx (Figure 3-30) is used to copy the graphic prescription from a previous series to the current series, provided the current prescription has the same patient position, patient entry, landmark, mode, FOV, slice thickness, spacing, and appropriate scan plane.

Figure 3-30 Copy Rx Button



Copy Rx opens a series list and displays all of the prescriptions which match the localizer image on the selected viewport. Clicking a previous series prescription automatically displays the slice locations on the displayed localizer images with the image in Viewport1 controlling the center location. Double-clicking automatically changes the displayed image to the image used to prescribe the original series and displays the slice locations. If there are no series meeting the copy requirements, the list of series does not appear and a message posts in the Advisory panel after selecting the **[Copy Rx]** button to inform you of no matching prescriptions.

Reset Center

The Reset Center option (Figure 3-31) allows you to graphically prescribe your locations on one slice location and redefine a new center image at another slice location.

Figure 3-31 Reset Center Button



Redefining the center image can be useful when prescribing axial orbits or shoulder images. For example, use a sagittal image where you see the optic nerves to prescribe the slice locations, then move to the center of the image and select the **[Reset Center]** button.

How Do I...

This section provides the step-by-step instructions for prescribing images. Specifically, it describes how to:

- Prescribe 2D graphic locations
 - Single and multi-group locations
 - Radial locations
- Prescribe 3D graphic locations
 - Single and multi-slab locations
 - Tracker location
- Prescribe SAT locations

Prescribe 2D Graphic Locations

Single and Multi-group Locations

3-Plane GRx allows you to define the scan locations on a localizer image using the same landmark while viewing the exact locations on three different image planes simultaneously. Either orthogonal or oblique imaging can be used.

Use this procedure to guide you through the process of graphically prescribing the scanning range for 2D prescriptions.

1. Enter the FOV in centimeters.
 - ♦ Choose one of the system pre-defined values or enter your own value in the text box. Use the scroll arrows to increase or decrease the selected value in steps of 2 cm.
 - ♦ Cover the area of anatomy selected for imaging. Anatomy outside the FOV in the phase direction results in aliasing.
2. Enter the slice thickness in millimeters.
 - ♦ Choose one of the system pre-defined values or enter your own value in the text box. Use the scroll arrows to increase or decrease the selected value in steps of 1 mm.
3. Enter the slice spacing in millimeters.
 - ♦ Select a spacing that reduces cross-talk. This is typically 20% of the slice thickness.
 - Cross-talk or overlap is caused by partial excitation of adjacent slices during RF excitation and refocusing by a 180° pulse. This causes a reduction in image contrast and SNR.
 - ♦ To reduce the effects of cross-talk choose Interleave (doubles scan time), a larger interscan spacing, or change to a 3D technique.
 - ♦ Choose one of the system pre-defined values or enter your own value in the text box. Use the scroll arrows to increase or decrease the selected value in steps of 1 mm.
4. Click the **Graphic Rx** icon.
 - ♦ Displays the 3-Plane GRx screen with the system selected default images loaded in the three viewports.

In Brief: Single and Multi-group Locations

1. Enter the FOV in centimeters.
2. Enter the slice thickness in millimeters.
3. Enter the slice spacing in millimeters.
4. Click the **Graphic Rx** icon.
5. Select the image desired for the localizer.
6. Click **[Copy]** if you desire to copy a prescription from a previous series that was scanned in the same plane, mode, FOV, slice thickness and spacing.
7. Magnify the image using the Zoom slider, if necessary.
8. Press **Shift** and click image in desired viewport to deposit the start location.
9. Click the Add handle and drag the cursor to the desired end location and release.
10. Press **Shift** and click image to add another group to the prescription. Repeat steps 8 and 9 as necessary.
11. Enter new values in the corresponding text boxes to adjust the FOV, spacing, slice thickness, and phase FOV, if necessary.

In Brief: Single and Multi-group Locations cont.

- 12. Adjust the number of slices, rotation, and start and end locations in any of the three viewports.
- 13. If necessary, move to desired center location and click **[Reset Center]**.
- 14. Click **[Accept]**.
- 15. Note the start, end, and center locations and number of slices.

- 5. Select the image desired for the localizer.
 - a) If necessary, click **[Select Series]** to choose a different series to be used as a localizer.
 - b) Select a series from the list.
 - c) Click **[OK]**.
 - ◆ Alternatively, you may click **[-]** and **[+]** to review the previous or next image in the series and select the desired image or type the desired series and/or image number in the text box. Example: series 2, image 5.



3-Plane GRx Text Box

- 6. Click **[Copy]** if you desire to copy a prescription from a previous series that was scanned in the same plane, mode, FOV, slice thickness, and spacing.
 - a) Select the series from the 3-Plane GRx Series List.
 - b) Click **[Accept]** in the copy window.
 - c) Skip to step 11.
- 7. Magnify the image using the Zoom slider, if necessary.
 - ◆ Enabling **Auto Update: Zoom** applies the magnification to all three viewports.
- 8. Press **Shift** and click image in desired viewport to deposit the start location.
 - ◆ Click the graphic line anywhere except on either the Rotate or Add handles and drag it to the desired start location.
 - ◆ Defines the start location.
 - ◆ The start graphic line appears on the image and displays on the corresponding intersections in the other viewports.
- 9. Click the Add handle and drag the cursor to the desired end location and release.
 - ◆ Defines the end locations.
 - ◆ Updates the corresponding intersections in the other viewports.
- 10. Press **Shift** and click image to add another group to the prescription. Repeat steps 8 and 9 as necessary.

11. Enter new values in the corresponding text boxes to adjust the FOV, spacing, slice thickness, and phase FOV, if necessary.
12. Adjust the number of slices, rotation, and start and end locations in any of the three viewports.
 - a) Click the Add handle to add or remove slices on the prescription.
 - b) Click the Rotate handle at the center of the slice group for oblique prescriptions to adjust the tilt angle.
 - c) Click and drag on any area of the Slice lines other than the handles to adjust the entire prescription.
13. If necessary, move to desired center location and click **[Reset Center]**.
 - ♦ Resets the center to the active viewport's location.
14. Click **[Accept]**.
 - ♦ Accepts the graphic prescription, closes the 3-Plane GRx screen, and allows you to continue with series prescription and acquisition.
 - ♦ Once you have accepted the prescription, you cannot make additional changes to the scanning range.
 - ♦ When you have prescribed multiple slices with multiple angles and you want all of the slices within each group to be acquired within a breath hold, enter the number of slices that comprises the largest group of slices as the locations before pause value. Entering a number less than this can result in more breath hold acquisitions.
15. Note the start, end, and center locations and number of slices.
 - ♦ Numeric values for the start/end locations, FOV center, and the number of slices prescribed, appear in the Scan Location text boxes in the Scanning Range area.

	A/P	S/I Center	R/L Center
Start	<input type="text"/>	<input type="text"/>	<input type="text"/>
End	<input type="text"/>	<input type="text"/>	<input type="text"/>
# Slices	<input type="text"/>		

2D Scan Locations

In Brief: Radial Locations

1. Click **[New Series]**.
2. Enter the Imaging Parameters.
3. Click the **Graphic Rx** icon.
4. Select the image desired for the localizer.
5. Select the radial direction.
6. Enter a value in the **# of Slices** and press **Enter**.
7. Enter a value in the **Partial Radial Spacing** text box and press **Enter**, if necessary.
8. Press **Shift** and click one of the images in 3-Plane GRx.
9. Adjust the radial prescription.
10. Press **Shift** and click image to add another group to the prescription. Repeat as necessary.
11. Click **[Accept]**.

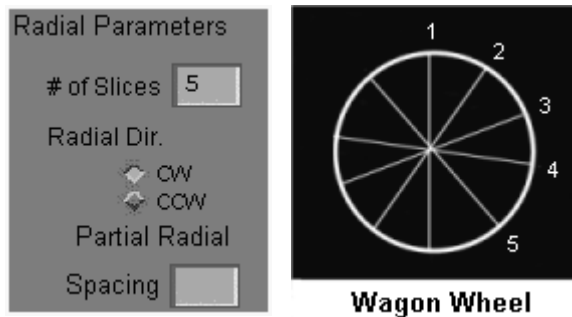
Prescribe 2D Graphic Locations**Radial Locations**

Radial prescriptions enable you to acquire multiple slices around a central axis in the same series. You can graphically prescribe radial locations and view their exact locations on three different image planes simultaneously. A radial or partial radial prescription can be useful for imaging, but not limited to, knees, MRCPs, myelograms, and hearts.

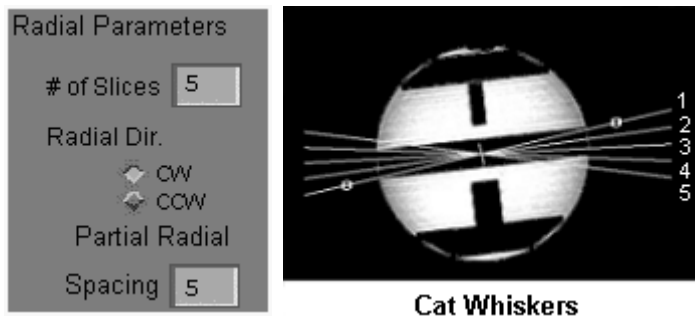
Use this procedure to guide you through the process of graphically prescribing a radial sequence.

1. Click **[New Series]**.
 - ◆ Located in the Rx Manager.
2. Enter the Imaging Parameters.
 - ◆ 2D Image Mode
 - ◆ Oblique Image Plane
 - ◆ FSE-XL, FRFSE-XL, SSFSE, SSFSE-IR, FastCard, FastCINE, or 2D FIESTA Pulse Sequence
3. Click the **Graphic Rx** icon.
 - ◆ Displays the 3-Plane GRx screen with the system selected default images loaded in the three viewports.
4. Select the image desired for the localizer.
 - a) If necessary, click **[Select Series]** to choose a different series to be used as a localizer.
 - b) Select a series from the list.
 - c) Click **[OK]**.
 - d) Alternatively, you may click **[-]** and **[+]** to review the previous or next image in the series and select the desired image or type the desired series and/or image number in the text box.
5. Select the radial direction.
 - ◆ The radial direction can be clockwise or counterclockwise.
 - ◆ The system defaults to clockwise rotation.

6. Enter a value in the **# of Slices** text box and press **Enter**.
- ◆ Controls the angle between the slices of the radial prescription.
 - ◆ The maximum number of slices in a single group is determined by the pulse sequence. If this limit is exceeded, the system will not accept the value. Enter a new value with a lower number of slices.
7. Enter a value in the **Partial Radial Spacing** text box and press **Enter**, if necessary.
- ◆ For a radial graphic prescription that looks like a wagon wheel, enter a value in the **# of Slices** text box and leave the **Spacing** text box empty.



- ◆ For a partial radial prescription that looks like cat whiskers, enter a value in the **# of Slices** text box and the degree of the angle between the slices in the **Spacing** text box.



8. Press **Shift** and click one of the images in 3-Plane GRx.
- ◆ Radial graphics appear on the image and display the corresponding intersections in other viewports.
 - ◆ If you "draw" the slices using the cursor, you are not able to get the angles.

9. Adjust the radial prescription.
 - a) Place the cursor in the center of the prescription and drag entire prescription to the desired location on image.
 - b) Click the Rotate handle and turn the prescription to the desired starting slice number.
10. Press **Shift** and click image to add another group to the prescription. Repeat as necessary.
 - ◆ If you need to specify a different number of slices for the next group, enter the desired value in the **# of Slices** text box in the Radial Parameters area, press **Enter**, and then deposit the group of slices.
 - ◆ The new, active radial graphic displays blue and the first, inactive group appears yellow.
11. Click **[Accept]**.
 - ◆ Accepts the radial prescription, closes the 3-Plane GRx screen, and allows you to continue with series prescription and acquisition.
 - ◆ When you have prescribed multiple slices with multiple angles and you want all of the slices within each group to be acquired within a breath hold, enter the number of slices that comprises the largest group of slices as the locations before pause value. Entering a number less than this can result in more breath hold acquisitions.

NOTE: Refer to Radial Prescription in the **What Do I Need to Know About...** section of this guide for detailed information on setting the number of locations before pause during scanning.

Prescribe 3D Graphic Locations

Single and Multi-slab Locations

Use 3-Plane GRx to graphically define 3D volume locations on a localizer image using the same landmark while viewing their exact locations on three different image planes simultaneously. Either orthogonal or oblique imaging can be used.

Use this procedure to guide you through the process of graphically prescribing the scanning range for 3D prescriptions.

1. Enter the FOV in centimeters.
 - ♦ Choose one of the system pre-defined values or enter your own value in the text box. Use the scroll arrows to increase or decrease the selected value in steps of 2 cm.
 - ♦ Cover the area of anatomy selected for imaging. Anatomy outside the FOV in the phase direction results in aliasing.
2. Enter the slice thickness in millimeters.
 - ♦ Choose one of the system pre-defined values or enter your own value in the text box. Use the scroll arrows to increase or decrease the value in steps of 0.1 mm.
3. Enter the number slices millimeters.
 - ♦ Each 3D group is able to overlap on another group for a multi group prescription. Enter the number of slices that you want to overlap between slabs within the same group to acquire a continuous series of slices—with no gaps.
 - ♦ An overlap of 25% is recommended, with uniform flip angle excitations, to minimize the venetian blind artifact on multi-slab 3D TOF acquisitions.
4. Enter the number of scan locations per slab.
 - ♦ Defines how many slices are in each volume.
 - ♦ Choose one of the system pre-defined values or enter your own value in the text box. Use the scroll arrows to increase or decrease the contiguous slice volume.

In Brief: Single and Multi-slab Locations

1. Enter the FOV in centimeters.
2. Enter the slice thickness in millimeters.
3. Enter the number slices in millimeters.
4. Enter the number of scan locations per slab.
5. Click the **Graphic Rx** icon.
6. Select the image desired for the localizer.
7. Click **[Copy]** if you desire to copy a prescription from a previous series that was scanned in the same plane, FOV, slice thickness, and spacing.
8. Magnify the image using the Zoom slider, if necessary.
9. Press **Shift** and click image in the desired viewport to deposit slab.
10. Click and drag the Rotate handle to display the “1” and “+” orientation for the desired slice direction order.

In Brief: Single and Multi-slab Locations cont.

11. Enter new values in the corresponding text boxes to adjust the number of slabs, FOV, slice thickness, overlap locations, number of locations per slab, and phase FOV, if necessary.
12. Add groups and position the 3D volume.
13. If necessary, move to desired center location and click **[Reset Center]**.
14. Click **[Accept]**.
15. Note the start, end, and center locations and the number of slabs.

5. Click the **Graphic Rx** icon.
 - ◆ Displays the 3-Plane GRx screen with the system selected default images loaded in the three viewports.
6. Select the image desired for the localizer.
 - a) If necessary, click **[Select Series]** to choose a different series to be used as a localizer.
 - b) Select a series from the list.
 - c) Click **[OK]**.
 - d) Alternatively, you may click **[-]** or **[+]** to review the previous or next image in the series and select the desired image or type the desired series and/or image number in the text box.
7. Click **[Copy]** if you desire to copy a prescription from a previous series that was scanned in the same plane, FOV, slice thickness, and spacing.
 - a) Select the series from the list.
 - b) Click **[Accept]** in the Copy window.
 - c) Skip to step 10.
8. Magnify the image using the Zoom slider, if necessary.
 - ◆ Enabling Auto Update: Zoom applies the magnification to all three viewports.
9. Press **Shift** and click image in the desired viewport to deposit slab.
 - ◆ Deposits a box representing the size of the imaging volume based on FOV, slice thickness, and number of scan locations selected.
 - ◆ Displays the corresponding intersections in the other viewports.
10. Click and drag the Rotate handle to display the “1” and “+” orientation for the desired slice direction order.
 - ◆ Displays the relationship of the 3D slice direction in the center of the volume. The side to which the “1” is closest is the side of the volume that begins with slice one.
11. Enter new values in the corresponding text boxes to adjust the number of slabs, FOV, slice thickness, overlap locations, number of locations per slab, and phase FOV, if necessary.

12. Add groups and position the 3D volume.
 - a) Click the Add handle to add or remove slabs on the volume prescription.
 - b) Click the Rotate handle on the volume for oblique prescriptions to adjust the tilt angle.
 - c) Click and drag on any area of the box other than the handles to move the entire prescription.
13. If necessary, move to desired center location and click **[Reset Center]**.
 - ♦ Redefines a new center image at another center location than where you graphically prescribed your locations.
14. Click **[Accept]**.
 - ♦ Accepts the graphic prescription, closes the 3-Plane GRx screen, and allows you to continue with series prescription and acquisition.
15. Note the start, end, and center locations and the number of slabs.
 - ♦ Numeric values for the start/end locations, FOV center, and the number of slabs prescribed, appear in the Scan Location text boxes in the Scanning Range area.

	A/P	S/I Center	R/L Center
Start	<input type="text"/>	<input type="text"/>	<input type="text"/>
End	<input type="text"/>	<input type="text"/>	<input type="text"/>
# Slabs	<input type="text"/>		

3D Scan Locations

Prescribe 3D Graphic Locations

Tracker Location

In Brief: Tracker Location

1. Click **[Tracker]**.
2. Press **Shift** and click an image in any of the three viewports.
3. Resize the tracker volume.
4. Angle and move the tracker to the desired position over the main vessel.
5. Reposition the 3D volume prescription, if necessary.
6. Click **[Accept]**.

3-Plane GRx allows you to access the Tracker Rx screen to deposit a tracker prescription and view its exact locations on the image viewport within which you initially deposit it. Either orthogonal or oblique imaging can be used. The 3-Plane GRx and the tracker prescription display together in the Tracker mode and both prescriptions can be manipulated.

Use this procedure to guide you through the process of graphically prescribing a tracker for 3D Fast TOF GRE or SPGR pulse sequences with SmartPrep prescriptions after prescribing your 3D volume in the 3-Plane GRx screen.

The tracker is only enabled if the SmartPrep option key is present and you have selected the SmartPrep Imaging Option.

1. Click **[Tracker]**.
 - ♦ Located on the 3-Plane GRx screen for 3D prescriptions.
 - ♦ Allows you to monitor a selected region of interest for the arrival of a contrast bolus.
2. Press **Shift** and click an image in any of the three viewports.
 - ♦ Deposits the tracker volume in the viewport you click.
3. Resize the tracker volume.
 - ♦ Recommended typical tracker size is a 20x20x20 mm volume to help minimize tracker movement.
 - ♦ Tracker length is represented by the size of the line.
 - ♦ Tracker thickness is represented by the middle cross hair.
 - a) Enter a value in the **Tracker Length** text box in millimeters.
 - b) Enter a value in the **Tracker Thickness** text box in millimeters.

4. Angle and move the tracker to the desired position over the main vessel.
 - ♦ Tracker placement should be no farther than $\frac{1}{4}$ above or below the center of the FOV to be scanned and should be completely contained within the vessel of interest.
 - a) Turn the Rotate handles to angle the tracker prescription with your vessel of interest.
 - b) Click and drag the tracker prescription to move its location.
5. Reposition the 3D volume prescription, if necessary.
6. Click **[Accept]**.
 - ♦ Accepts the Tracker prescription, closes the Tracker Rx screen, brings you back to the 3-Plane GRx screen and allows you to continue with series prescription and acquisition.

Prescribe SAT Locations

In Brief: Prescribe SAT Locations

1. Click the **SAT** icon.
2. Select the image desired for the localizer.
3. Click **[Copy]** if you desire to copy a SAT prescription from a previous series and all SATs are deselected from the current prescription.
4. Magnify the image using the Zoom slider, if necessary.
5. Prescribe the desired spatial saturation bands.
6. Resize and move the SAT band to its desired location.
7. Prescribe the desired concatenated spatial saturation, if necessary.
8. Prescribe the desired chemical saturation, if necessary.
9. Click **[Accept]**.

Use the following procedure to define SAT bands on your images. 3-Plane SAT allows you to graphically prescribe SAT bands on an image from a series within the current exam while viewing your GRx in three different image planes. This option is also used for prescribing a concatenated SAT or prescribing a chemical saturation technique.

Use this procedure to guide you through the process of prescribing SAT locations during scanning.

1. Click the **SAT** icon.
 - ◆ Located in the Additional Parameters area or on the 3-Plane GRx screen.
 - ◆ Displays the SAT screen with any 3-Plane GRx locations that may have been deposited.
2. Select the image desired for the localizer.
 - a) If necessary, click **[Select Series]** to choose a different series to be used as a localizer.
 - b) Select a series from the list.
 - c) Click **[OK]**.
 - d) Alternatively, you may also click **[-]** and **[+]** to review the previous or next image in the series and select the desired image.
3. Click **[Copy]** if you desire to copy a SAT prescription from a previous series and all SATs are deselected from the current prescription.
 - a) Select the series from the list.
 - b) Click **[Accept]** in the Copy window.
 - c) Skip to step 9.
4. Magnify the image using the Zoom slider, if necessary.
 - ◆ Enabling **Auto Update: Zoom** applies the magnification to all three viewports.

5. Prescribe the desired spatial saturation bands.
 - ◆ You are able to drop up to six SAT bands at one time on any of the three viewports if the pulse sequence supports it.
 - ◆ The intersections of the SAT bands display on the other 2 viewports.
 - ◆ The default SAT thickness is 80 mm for most sequences.
 - ◆ If you do not enter any value in the location text box, the SAT band is placed at the edge of the FOV.
 - a) Click **[S]**, **[I]**, **[A]**, **[P]**, **[R]**, or **[L]** to prescribe directional spatial SAT bands.
 - b) Accept the default thickness and location or enter a value for thickness and location.
 - c) Position the cursor on the image at the desired location for the inside edge of the saturation band, press **Shift** and click.
6. Resize and move the SAT band to its desired location.
 - a) Click and drag the Thickness handle to change the width of the band or type in a value in the **Thickness** text box.
 - b) Click and drag the Rotate handles on the leading edge of the SAT band to turn it.
 - c) Click and drag either edge of the SAT band to change its location. Do not click on the Rotate or Thickness handles to move it.
7. Prescribe the desired concatenated spatial saturation, if necessary.
 - ◆ Two concatenated saturation pulses can be placed parallel to the acquisition slice when used with a sequential series, or with an orthogonal series with two acquisitions.
 - a) Click saturation bands in the slice direction.
 - b) Click **[Concat SAT]**.
8. Prescribe the desired chemical saturation, if necessary.
 - a) Select **Fat**.
 - b) Select **Water**.

9. Click **[Accept]**.
 - ◆ Accepts the SAT prescription, closes the 3-Plane SAT screen, and allows you to continue with series prescription and acquisition.

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Chapter 4

Fast Spin Echo Pulse Sequences

Introduction

There are several new additions and improvements made to the Fast Spin Echo (FSE) family of pulse sequences. These new modifications improve image quality by increasing image contrast and image signal, or by decreasing overall scan times.

The following pulse sequences are new or enhanced modifications of existing pulse sequences:

- Three Dimensional Fast Spin Echo (3D FSE)
- T1 Fluid Attenuated Inversion Recovery (T1 FLAIR)
- Single Shot Fast Spin Echo (SSFSE)
- Single Shot Fast Spin Echo Inversion Recovery (SSFSE-IR)
- Single Shot Fast Spin Echo - Accelerated (SSFSE-XL)

In addition, this chapter answers the following questions:

1. What is Dynamic R1?
2. What is SSFSE-XL?

What Do I Need to Know About...

This section presents the concepts necessary to understand all FSE pulse sequences. Specifically you need to understand:

- Fast Spin Echo
 - Dynamic R1
- T2 FLAIR
- T1 FLAIR
 - Associated Imaging Options
- Single Shot Fast Spin Echo and Single Shot Fast Spin Echo Inversion Recovery
 - Associated Imaging Options
- Single Shot Fast Spin Echo - Accelerated (SSFSE-XL)
 - Associated Imaging Options

Fast Spin Echo

The FSE pulse sequence can be acquired in two-dimensional (2D) or three-dimensional (3D) modes. The sequence is performed by an initial 90° pulse followed by additional 180° radio frequency (RF) pulses. An enhancement to the 3D FSE sequence is listed below.

Dynamic R1

Dynamic R1 is an adaptation to the 3D FSE pulse sequence. It is designed to increase the Signal-to-Noise Ratio (SNR) for large Field of Views (FOVs). In a 3D FSE sequence, the analog receiver gain is typically set to adequately digitize the signal at the center of K-space, leaving the signal at the edge of K-space subject to digitalization noise. With Dynamic R1, the receiver values increase at the edge of K-space. This reduces digitalization noise and produces images with increased SNR.

To activate, Dynamic R1 perform this pre-scanning procedure:

1. Select **3D FSE** from the Pulse Sequences window
2. Enter `3dfsedr1` in the **PSD Name** textbox.
3. Enter your Imaging Parameters.
4. Click [**Save Series**].

5. Click **[Prepare to Scan]**.
6. Click **[Auto Prescan]**.
7. Click **[Manual Prescan]**.
 - ♦ Confirm the R2 value is at least 14. This ensures SNR is at optimal gain.
 - ♦ If R2 is less than 14, increase it to 14 and lower the R1 by a factor of 1.
8. Click **[Close]**.
9. Click **[Scan]**.

To determine if Dynamic R1 might improve your images prescribe a large single slab 3D volume, then during manual prescan, check the receiver gain (R1) of the imaging volume. If the value is less than 6, consider using Dynamic R1.

T2 FLAIR

The T2 FLAIR selection replaces the original FLAIR selection within the Pulse Sequence window. All functions and FLAIR sequence performances can now be activated through the T2 FLAIR selection. To activate the T2 FLAIR sequence select **T2 FLAIR** in the Pulse Sequence window.

NOTE: Pausing a FLAIR acquisition, during scanning may cause image artifacts and should be avoided.

Associated Imaging Options

There are several Imaging Options that can be used in conjunction with the T2 Flair pulse sequence. In Table 4-1, the Xs indicate the options available for use with the T2 FLAIR pulse sequence.

Table 4-1 T2 FLAIR Pulse Sequence Imaging Options.

Imaging Options			
	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel	X	Surface Coil Intensity Correction
	Respiratory Compensation		Classic

Imaging Options			
	Magnetization Transfer	X	Sequential
	Cardiac Gating/Triggering		Respiratory Gating/Triggering
X	Tailored RF	X	IR Prepared
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024	X	ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Fluoro Trigger		

T1 FLAIR

The T1 FLAIR pulse sequence is designed to reduce the T1 weighted imaging scan time, as compared to T1 weighted Spin Echo (SE) imaging scan times. It also is designed to achieve better tissue contrast-to-noise (CNR) and tissue signal-to-noise (SNR).

To activate the T1 FLAIR sequence select **T1 FLAIR** in the Pulse Sequence window. This Pulse Sequence Database (PSD) now operates in both the Picture This mode and in the Site Protocol mode. T1 FLAIR images are annotated as “t1flair/90” in the lower left corner of images.

NOTE: The Site Protocol mode allows you to adjust prescription parameters and save the protocol in your site library.

NOTE: Pausing a FLAIR acquisition, during scanning may cause image artifacts and should be avoided.

Associated Imaging Options

There are several Imaging Options that can be used in conjunction with the T1 Flair pulse sequence. In Table 4-2, the Xs indicate the options available for use with the T1 FLAIR pulse sequence.

Table 4-2 T1 FLAIR Pulse Sequence Imaging Options.

Imaging Options			
	None	X	Variable Bandwidth
X	Flow Compensation	X	No Phase Wrap
	POMP		Extended Dynamic Range
X	Square Pixel	X	Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer	X	Sequential
	Cardiac Gating/Triggering		Respiratory Gating/Triggering
X	Tailored RF		IR Prepared
	DE Prepared		Multi-Phase
X	Full Echo Train		CCOMP
X	ZIP 1024	X	ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Fluoro Trigger		

NOTE: Tailored RF and Sequential are inherent to this sequence and can not be turned off.

Single Shot Fast Spin Echo and Single Shot Fast Spin Echo-Inversion Recovery

To activate the SSFSE-IR pulse sequence you must select **SSFSE** from the Pulse Sequence window and **IR Prepared** from the Imaging Options window. SSFSE can be activated by selecting **SSFSE** from the Pulse Sequence window.

Optimized Fractional NEX is a new User CVs option available with both SSFSE and SSFSE-IR pulse sequences. Optimized Fractional NEX is accessed in the **User CVs** window. This option is only recommended for

MRCP exams, but is available for all SSFSE applications. Refer to the SSFSE-XL section of this chapter for additional information on Optimized Fractional NEX. You can also enter the maximum number of echoes to be utilized in the current sequence, in the User CVs window. The maximum of echoes allowed for both SSFSE and SSFSE-IR pulse sequences is 184.

Associated Imaging Options

There are several Imaging Options that can be used in conjunction with the SSFSE and SSFSE-IR pulse sequences. In Table 4-3, the Xs indicate the options available for use with the SSFSE and SSFSE-IR pulse sequences

Table 4-3 SSFSE and SSFSE-IR Pulse Sequence Imaging Options

Imaging Options			
X	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel		Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer	X	Sequential*
X	Cardiac Gating/Triggering	X	Respiratory Gating/Triggering
	Tailored RF	X	IR Prepared*
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Fluoro Trigger		

NOTE: *The Sequential and IR Prepared imaging options should only be used when performing the SSFSE-IR pulse sequence.

SSFSE-XL

SSFSE-XL is a keyed option available for your MR system. It is a modification of the original SSFSE pulse sequence. This feature is designed to improve the CNR and SNR seen in MRCP images.

Modifications include:

- Flexible TE ranges
- Selectable TR values
- Additional bandwidth ranges
- Increased number of allowable echoes.

The SSFSE-XL sequence is activated by selecting **SSFSE** from the pulse sequence window. If you have this feature the original SSFSE pulse sequence will not be available to you. Differences between the two psds are outlined in Table 4-4.

Table 4-4 SSFSE vs. SSFSE-XL

	SSFSE	SSFSE-XL
TE	Only the values from the TE text box pull-down list can be utilized.	Any value including or between the minimum and maximum values displayed on the advisory panel can be utilized.
TR	Not selectable; your system automatically selects the best value for you.	Any value between and including minimum to infinity can be utilized.
ETL	The maximum ETL range is 184 echoes. The system automatically chooses the best ETL for you.	The maximum ETL range is 264 echoes. You choose the ETL you want.
Bandwidth	Only 20.83, 32.25 and 62.5 bandwidths can be utilized. System defaults to 62.5 kHz.	System allows 20.83, 25.00, 31.25, 41.66 and 62.5 bandwidth values to be utilized. System defaults to 62.5 kHz.

Flexible TE Range

Flexible TE range allows for two different methods of transversing K-space, Linear Phase Encoding and Reverse Phase Encoding. Both SSFSE pulse sequences select the phase encoding scheme according to the prescribed TE. Linear Phase Encoding is used for short to medium range TEs. Reverse Phase Encoding is used for long range TEs. Loss of SNR from T2

decay is minimized with Reverse Linear Phase Encoding, since it acquires more echoes earlier in the Echo Train compared to Linear Phase Encoding. The system automatically defaults to the Reverse Phase Encoding, unless a minimum TE is prescribed. By varying the transversing of K-space, the system automatically employs the best possible use of recording the echoes, thus producing the best possible image quality.

Selectable TR Values

You can now also choose a TR value. By selecting a TR, you can force a pause to occur between each slice. For example, if you select 20 seconds, data would be acquired in a two second burst with a eighteen second rest for the patient. This eliminates the need to manually pause between slices, it also helps to reduce image cross talk. If you desire the acquisition to perform with no pauses select **Minimum** for the TR.

Receiver Bandwidth

Additional Receiver bandwidths (RBw) have now been incorporated into this PSD. This allows more flexibility for increasing SNR, therefore, increasing image quality.

Fractional Phase FOV Ranges

A wider range of fractional phase FOV is now available. The phase FOV range is from 0.5 to 1.0. Values can be increased in increments of 0.1. This range of phase FOV values allows you to choose the best phase FOV to image desired anatomy, without sacrificing too much resolution and signal from your image.

User Control Variables

Fractional NEX Optimization is an option selected through the **User CVs** window in the **Additional Parameters** area. When Fractional NEX Optimization is off, echoes are discarded to achieve the prescribed TE. This option would normally be kept off when performing exams other than MRCP. It uses the half NEX technique which forces the system to use approximately half of the phase encodings needed to fill K-space, allowing the system to achieve the shortest scan time possible. With Fractional NEX Optimization on, the echoes that would normally be discarded are now acquired and used to increase the number of overscans, thus increasing the T2 weighting of the image. Image annotation will reflect fractional NEX. This option is only recommended for imaging long T2 exams, especially imaging colon and pancreas anatomy.

Maximum number of echoes available for SSFSE is another option selected through the User CVs window. It allows you to choose the number of echoes utilized with the current acquisition. The maximum allowed for SSFSE-XL sequences is 264.

NOTE: Coaxial slices can be acquired in separate groups.

Associated Imaging Options

In Table 4-5, the Xs indicate the options available for use with the SSFSE-XL pulse sequences.

Table 4-5 SSFSE-XL Pulse Sequence Imaging Options

Imaging Options			
X	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel		Surface Coil Intensity Correction
X	Respiratory Compensation		Classic
	Magnetization Transfer	X	Sequential
X	Cardiac Gating/Triggering	X	Respiratory Gating/Triggering
	Tailored RF	X	IR Prepared
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024	X	ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Fluoro Trigger		

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Chapter 5

3D FIESTA Pulse Sequence

Introduction

The Fast Imaging Employing STeady-state Acquisition (FIESTA) is a fully balanced steady-state coherent imaging pulse sequence designed to produce high signal-to-noise ratio (SNR) images at very short sequence times (TRs).

This chapter explains the pulsing components and timing factors directly related to the 3D FIESTA imaging pulse sequence. It also explains the concepts and the step-by-step instructions to help you learn how to:

- Optimize 3D FIESTA Images
- Prescribe a 3D FIESTA Sequence

In addition, this chapter answers the following questions:

1. What is FIESTA?
2. When would I use a 3D FIESTA pulse sequence?
3. How do I get the shortest TR?
4. What are the imaging characteristics of a 3D FIESTA pulse sequence?
5. Which imaging options can be used with the 3D FIESTA pulse sequence?
6. What are some applications of the 3D FIESTA sequence?

What Do I Need to Know About...

This section presents the concepts necessary to understand imaging with the 3D FIESTA pulse sequence. Specifically, you need to understand the following concepts:

- 3D FIESTA Basics
- Imaging Effects
- Image Characteristics
- Associated Imaging Options
- Applications

3D FIESTA Basics

The Fast Imaging Employing STeady-state Acquisition (FIESTA) sequence is a fully balanced steady-state coherent imaging pulse sequence designed to produce high SNR images at very short TRs. The pulse sequence uses fully balanced gradients to re-phase the transverse magnetization at the end of each TR interval. For very short TR sequences, the resulting signal intensity is independent of TR and related to (T_2/T_1) . More importantly, the short TRs are essential to maintain spin phase coherence. Phase coherence is required to maintain coherent transverse magnetization and eliminate artifacts generated by magnetic susceptibility induced phase shifts. Thus, the advantages of FIESTA can only be realized with very short TR where $(TR \ll T_2)$ and $(TR \ll 1/b)$ where b is the local frequency shift caused by inhomogeneity.

NOTE: \ll indicates “much less than”.

Tissue contrast is generated based on the ratio of the spin-spin relaxation time (T_2) and the spin-lattice relaxation time (T_1). Hence, the pulse sequence accentuates the contrast of spins with high T_2/T_1 ratios (such as cerebral-spinal fluid, water, and fat) while suppressing signal from tissues with low T_2/T_1 ratios (such as muscle and myocardium).

The 3D FIESTA sequence can be used for whole body imaging and can be used in clinical applications that benefit from the differentiation of contrast between tissues of low T_2/T_1 ratios (low signal intensity) and high T_2/T_1 ratios (high signal intensity). The 3D FIESTA technique can be useful for, but not limited to, imaging structures in motion such as abdominal imaging of the bile ducts or for rapid acquisition of static structures with high spatial resolution such as the cochlea or joint imaging.

Imaging Effects

The sequence parameters have different effects that contribute to 3D FIESTA images. Table 5-1 summarizes the imaging effects relating to 3D FIESTA and is provided to help you understand the trade-offs that occur when you change the values for a particular parameter.

Table 5-1 Imaging Effects with 3D FIESTA

Parameters	Contrast (T ₂ /T _s)	Temporal Resolution	Spatial Resolution	SNR	Scan Time	Artifacts
TR ↓	↑	↑	N/A	↑	↓	↓
TE ↓	↑	N/A	N/A	↑	↓	↓
Flip Angle ↑	↑	N/A	N/A	↑	N/A	N/A
RBw ↑	↑	↑	N/A	↓	↓	↓
VPS ↑	N/A	↑	N/A	N/A	↓	↑
Matrix ↑	N/A	N/A	↑	↓	↑	N/A
Slice Thickness ↓	N/A	N/A	↑	↓	N/A	N/A
FOV ↓	N/A	N/A	↑	↓	N/A	*

NOTE: *There is always a direct correlation between FOV and artifact. In certain instances, with anatomical size and FOV, some artifact can occur (wrap). In most other circumstances, there is not a correlation.

Imaging Characteristics

3D FIESTA sequences produce high signal to noise images with enhanced contrast and temporal resolution. This sequence provides excellent contrast between soft tissues and fluids with reduced repetition times to minimize motion artifacts.

There are several factors you should consider when using 3D FIESTA:

- 3D FIESTA supports 512 matrix.
- The TE is fixed at the minimum full value.
- When using gating turn on the Reverse Loop Order CV at the User CVs screen by typing 1.
 - When Reverse Loop Order is OFF (0), the system scans all lines of K-space along the slab encoding direction per heartbeat; therefore, the scan time is equivalent to a number of heartbeats equal to the number of phase encoding lines to be collected. For example, if you have a phase matrix of 128 selected with a Phase FOV of one, your scan time takes 128 heartbeats to complete.
 - When Reverse Loop Order is on (1), the system collects all lines of K-space along the phase encoding direction per heartbeat; therefore, your scan time is equivalent to a number of heartbeats equal to the number of slab locations selected. For example, if you have selected a slab of 44 locations, your scan time takes 44 heartbeats to complete.

Associated Imaging Options

Imaging Options provide image processing or filters for enhancing anatomical features or reducing noise. In Table 5-2, the Xs indicate the imaging option available for use with the 3D FIESTA pulse sequence.

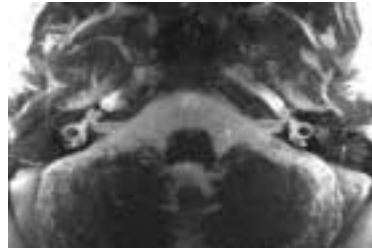
Table 5-2 3D FIESTA Pulse Sequence Imaging Options

Imaging Options			
X	None	X	Variable Bandwidth
	Flow Compensation	X	No Phase Wrap
	POMP	X	Extended Dynamic Range
X	Square Pixel	X	Image Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer		Sequential
X	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF		IR Prepared
	DE Prepared	X	Multi Phase
	Full Echo Train		CCOMP
X	ZIP 1024	X	ZIP 512
X	Zip x 2	X	ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

Applications

3D FIESTA imaging is intended for the whole body. Imaging applications for 3D FIESTA include screening of the spine for spinal disk hernias or disk intrusions into the spinal canal (spinal cord block), level of obstruction in hydrocephalus, biliary obstruction, cholangio-pancreatography, and in the visualization of the internal auditory canals (IACs).

Figure 5-1 3D FIESTA image of the IACs



3D FIESTA

- Recommendations for getting the shortest TR:
 - For high-resolution imaging (≤ 0.5 mm), RBw of 42 kHz appears to yield a shorter TR. This is due to gradient heating limitation. Otherwise, 125 kHz would give the shortest TR. RBw choices are 125, 100, 83.3, 62.5, 41.57, and 31.25 kHz.
 - Try smaller flip angles (40°) first and increase it slowly, every five degrees, to see if SAR limits your minimum TR. Compromise should be made between highest flip angle (70°) and shortest achievable TR (< 6 ms). The longest achievable flip angle is 90° .

How Do I...

This section provides the step-by-step instructions for prescribing 3D FIESTA imaging pulse sequences. Specifically, it describes how to:

- Prescribe a 3D FIESTA Sequence

This section also provides the following 3D FIESTA images and example protocols.

- Sagittal Spine
- IACs
- Body
- MRCP

Decision Matrix

A decision matrix is used in this section to provide examples of what values could be selected for prescribing a particular sequence. The purpose of the decision matrix is to help you understand the trade-offs that occur when you change the values for a particular parameter and to provide a framework with which you may build your own unique protocol.

The example protocols provide information on what could be used for these pulse sequences and are not to be considered recommendations by GE Medical Systems. For specific protocols, refer to the protocols on your system.

In addition to listing the information you need to select on the system, the “What You Select” column of the matrix uses two other conventions.

- N/A indicates that the imaging parameter is not applicable to the pulse sequence example.
- N/S indicates that the imaging parameter is not selectable in the pulse sequence example. The system automatically selects these imaging parameters.



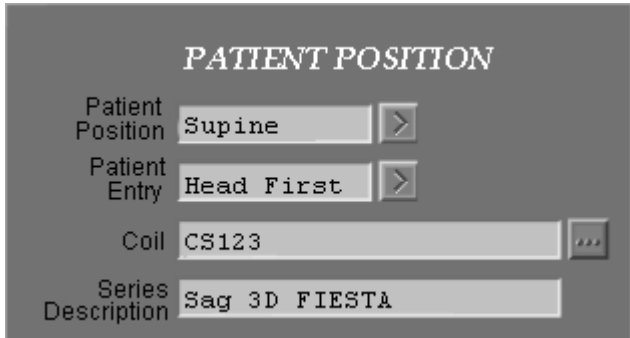
CAUTION: Provide all patients with ear protection prior to any scan to help avoid possible hearing impairment. Acoustic noise levels can exceed 99 dbA in the magnet bore.

Prescribe a 3D FIESTA Sequence

3D sagittal images of the spine can be acquired with the FIESTA sequence. The 3D FIESTA pulse sequence accentuates cerebral spinal fluid, water, and fat, while suppressing muscle tissue.

The decision matrix (Table 5-3) is only for prescribing a 3D FIESTA scan. The following example protocol in the matrix is for a 3D Sagittal Spine.

Table 5-3 3D FIESTA Protocol Example (Sagittal Spine)

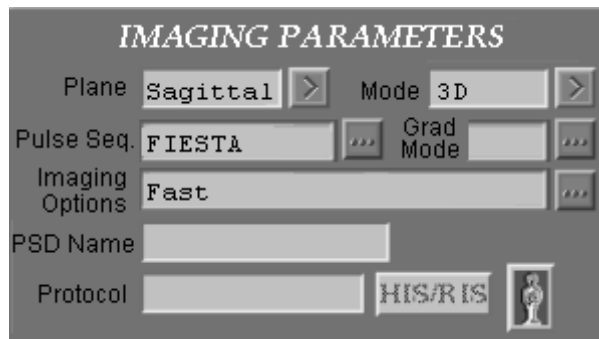
3D FIESTA Protocol Example		
What You Select		Selection Notes
Scan Rx Desktop		
Scan Rx	Acquire a localizer series	Allows Graphic Rx to become available so you can prescribe slices graphically on the localized image.
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol window becomes active.
Patient Position		
		
Patient Position	Supine	Compatible with any patient position.
Patient Entry	Head First	Compatible with head or feet first entry.
Coil	Phased Array > CS123	Use a coil that produces the optimum coverage and SNR.
Series Description	Enter a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

3D FIESTA Protocol Example

What You Select

Selection Notes

Imaging Parameters



Plane	Sagittal	Compatible with any scan plane, except 3-plane. Select the plane that best meets your clinical need.
Mode	3D	Allows prescription of a three-dimensional FIESTA sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	FIESTA	Allows prescription of a FIESTA pulse sequence.
Imaging Options		Select imaging options that optimize SNR, spatial resolution, number of slices and reduce motion artifacts.
PSD Name	N/A	
Protocol	N/A	

3D FIESTA Protocol Example

What You Select

Selection Notes

Scan Timing

SCAN TIMING

of Echoes 1 2 4

TE

TE2

TR

Inv Time

TI2

Flip Angle

Echo Train Length

Bandwidth

Bandwidth2

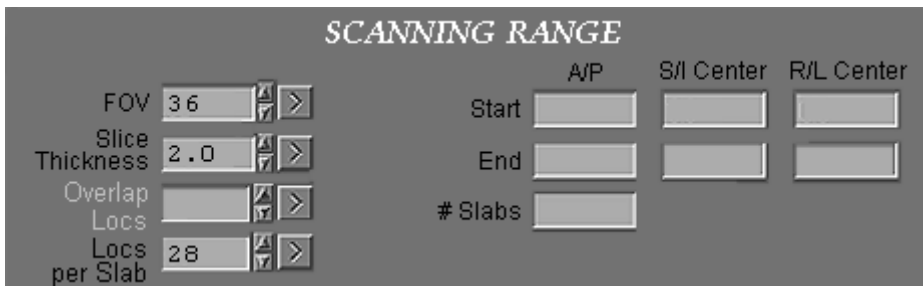
# of echoes	N/S	One echo is automatically selected.
TE	Min Full	The typical TE value is minimum full.
TE2	N/A	
TR	N/S	The minimum TR is selected automatically.
Inv Time	N/A	
TI2	N/A	
Flip Angle	Enter 50 in the text box.	The typical flip angle value for the spine is 45° to 55°.
Echo Train Length	N/A	
Bandwidth	125	The RBw choices are 125, 100, 83.3, 62.5, 41.57, and 31.2 kHz. 12 kHz yields the shortest TR for a slice thickness > 0.5 mm.
Bandwidth2	N/A	

3D FIESTA Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	Enter 36 in the text box.	Select a FOV that covers the anatomy of interest. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	2.0	The typical slice thickness value for a 3D spine is 2 to 3 cm. Thin slices produce increased resolution and decreased SNR.
# of Scan Locs	Enter 28 in the text box.	Available selections are 8 to 128 locations. There are always two slices on either end of the slab that are discarded. Factor these four slices into your selection.
Start, End Locations		The start and end locations are programmed from the Graphic Rx program after the slabs are prescribed.
# Slabs		Determined by the number of scan locations and the desired range of anatomy to be covered.

Acquisition Timing

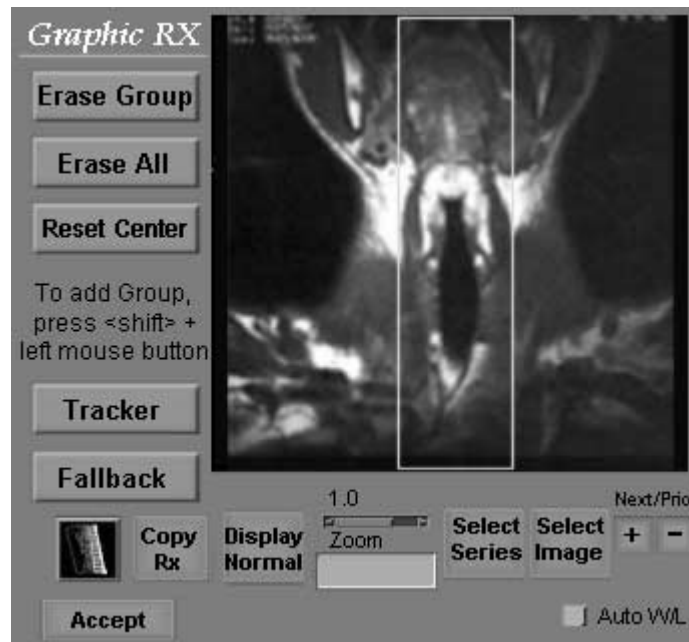


Freq	384	Increasing the frequency matrix increases resolution, while decreasing SNR and the number of available slices.
Phase	256	Phase controls scan time and may control resolution.
NEX	1	One NEX for sufficient SNR and a reasonable scan time.

3D FIESTA Protocol Example

What You Select		Selection Notes
Phase FOV	1.00	Select a phase FOV of one to prevent wrapping of anatomy.
Freq DIR	S/I	The direction displayed is the default frequency direction which is typically the long axis of the image. Leave the frequency direction unswapped.
Auto Center Freq	Water	The CF peak that will be set during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Turn Autoshim on when using an off center FOV and on the first series of an exam.
Phase Correct	Off	Provides no additional benefits and increases prescan time.
# of Acqs Before Pause	N/A	

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Prescribe the slices to display the slab for graphic prescription. Select the adjustment handles to angle, draw, and remove slabs. Position the volume to cover anatomy of interest and view the Advisory Panel to note the maximum number of slabs per acquisition and the number of acquisitions you are prescribing.
Copy Rx	[Copy Rx] (optional)	If you had previously graphically prescribed a series with the same plane, FOV, and slice thickness, the prescription can be copied to the exact locations of the prior series.

3D FIESTA Protocol Example		
What You Select		Selection Notes
Erase Group	[Erase Group] (If necessary)	Eliminates the graphic prescription from the screen and allow you to start over.
Reset Center	[Reset Center] (if necessary)	Re-establishes the FOV center on a different localized slice.
Accept	[Accept]	Confirms the cursor position and close Graphic Rx.
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Scan	[Scan]	Initiates the acquisition.

3D Sagittal Spine

A sagittal spine scan can be acquired with a 3D FIESTA pulse sequence. This sequence can be used for screening the spine for spinal disk hernias or intrusions into the spinal canal. The sequence accentuates cerebral spinal fluid, water, and fat, while suppressing muscle tissue. Figure 5-2 shows a sagittal image of the spine acquired with a 3D FIESTA sequence. Table 5-4 gives you a brief look at an example protocol. The parameters may vary depending on your needs.

Figure 5-2 3D FIESTA

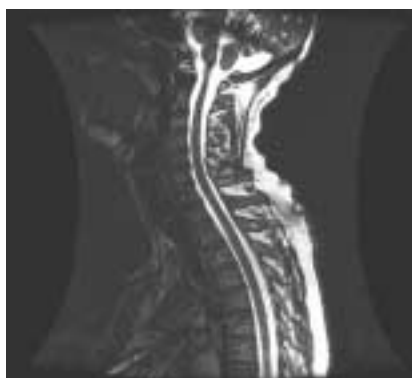


Table 5-4 3D FIESTA Example Spine Protocol

Plane	Mode	Pulse Sequence	PSD Name	TE	TR	Flip Angle	RBw	FOV	Slice Thickness	# of Scan Locs
Sagittal	3D	FIESTA	N/A	Min Full	N/A	45-55	125	~36	2 to 3	28 slices
Matrix	NEX	Phase FOV	Freq Direction	Center Frequency	Auto Shim	Phase Correct	Imaging Options	Sat Pulses	Comments	
384x256	1	1	Unswap	Water	On	Off		None	CTL coil recommended	

3D IACs

An axial or coronal scan of the IACs can be acquired with a 3D FIESTA pulse sequence. This sequence can be useful to produce a high signal to noise image with enhanced contrast and temporal resolution in the visualization of the cochlea. Figure 5-3 shows an axial image of the IACs acquired with a 3D FIESTA sequence. Table 5-5 gives you a brief look at an example protocol. The parameters may vary depending on your needs.

Figure 5-3 3D FIESTA

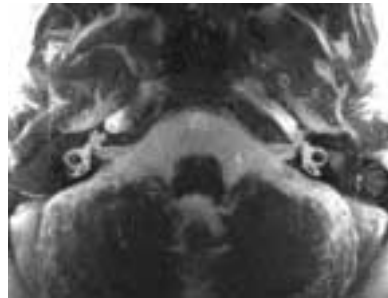


Table 5-5 3D FIESTA Example IAC Protocol

Plane	Mode	Pulse Sequence	PSD Name	TE	TR	Flip Angle	RBw	FOV	Slice Thickness	Slice Spacing
Oblique	3D	FIESTA	N/A	Min Full	N/A	70	125	16 to 28*	0.8 to 1.0	0.0

Matrix	NEX	Phase FOV	Freq Direction	Center Frequency	Auto Shim	Phase Correct	Imaging Options	Sat Pulses	Comments
512x512	1	1	Unswap	Water	On	Off		None	Dual or head coil recommended

NOTE: *Reduced FOVs attained by reducing matrix.

3D Body

An axial or coronal abdominal scan can be acquired with a 3D FIESTA pulse sequence. This sequence provides excellent contrast between soft tissues and fluids with reduced repetition times to minimize motion artifacts. Figure 5-4 shows a coronal image of the abdomen acquired with a 3D FIESTA sequence. Table 5-6 gives you a brief look at an example protocol. The parameters may vary depending on your needs.

Figure 5-4 3D FIESTA



Table 5-6 3D FIESTA Example Body Protocol

Plane	Mode	Pulse Sequence	PSD Name	TE	TR	Flip Angle	RBw	FOV	Slice Thickness	# of Scan Locs
Axial or Coronal	3D	FIESTA	N/A	Min Full	N/S	45 to 55	125	~40	3.0	20 to 40

Matrix	NEX	Phase FOV	Freq Direction	Center Frequency	Auto Shim	Imaging Options	Comments
256x192	1	1	Unswap	Water	On	ZIP x 2, 512 ZIP optional	Proper coil selection to cover anatomy

3D MRCP

An axial or coronal MR Cholangiogram (MRCP) scan can be acquired with a 3D FIESTA pulse sequence. This sequence provides enhanced contrast and temporal resolution for imaging of the bile ducts. Figure 5-5 shows an image of the bile ducts acquired with a 3D FIESTA sequence. Table 5-7 gives you a brief look at an example protocol. The parameters may vary depending on your needs.

Figure 5-5 3D FIESTA Contrast Enhanced Image



Table 5-7 3D FIESTA Example MRCP Protocol

Plane	Mode	Pulse Sequence	PSD Name	TE	TR	Flip Angle	RBw	FOV	Slice Thickness	# of Scan Locs
Axial or Coronal	3D	FIESTA	N/A	N/S	N/S	40	125	~40	2.8	44

Matrix	NEX	Phase FOV	Freq Direction	Center Frequency	Auto Shim	Phase Correct	Imaging Options	Sat Pulses	Comments
224x256	0.5	1	Unswap	Water	On	Off		None	Surface coil recommended

Chapter 6

Clinical Spectroscopy Pulse Sequences

Introduction

The PROstate Spectroscopy and imaging Exam (PROSE) is a new addition to the family of clinical spectroscopy pulse sequences. It is designed to produce spectra of metabolites in the human prostate area. This aids a trained physician in making clinical diagnosis of prostate diseases.

This chapter explains the characteristics of the PROSE sequence. It also explains the concepts and the step-by-step instructions to help you learn how to:

- Prescribe a PROSE sequence

In addition, this chapter answers the following questions:

1. What is PROSE?
2. When would you use a PROSE pulse sequence?
3. Which imaging options can be used with a PROSE pulse sequence?
4. Why would you use a PROSE pulse sequence?

NOTE: Refer to the Clinical Spectroscopy Pulse Sequences Chapter in the Signa® MR/i™ with Signa Select™ (ASP2) guide for additional information on spectroscopy pulse sequences.

What Do I Need to Know About...

This section presents the concepts necessary to understand imaging with the PROSE pulse sequence. Specifically you need to understand:

- PROSE Description
- Prostate Spectrum
- Scan Parameters
 - Suppression Techniques
- Spectroscopy Characteristics
- Associated Imaging Options
- Applications



CAUTION: The safety precautions needed for Magnetic Resonance Spectroscopy (MRS), are identical to those required for any other Signa® examination. Review the Working Safely chapter in the Signa® MR/i™ with Signa Select™ (ASP2) Guide to make sure that the MR environment is as safe as possible for all patients.

PROSE Description

PROSE is a diagnostic technique that provides, in a non-invasive manner, estimates of concentrations of metabolites present in the prostate gland. It is an adaptation to the Point RESolved Spectroscopy (PRESS) sequence, with the characteristics of a three-dimensional (3D) Chemical Shift Imaging (CSI) Focal Brain spectroscopy sequence. Like PRESS, PROSE incorporates a double spin echo sequence that uses a 90° excitation pulse with two slice selective refocusing radio frequency (RF) pulses to generate a spectrum. Similar to 3D CSI Focal Brain, PROSE incorporates 3D voxel placement.

Prostate Spectrum

There are several peaks that make up the different components in a prostate spectrum. The position of each peak, as with brain spectra, is determined by the chemical composition and resulting frequency shift. The peaks represent different chemical species or molecules. Table 6-1 lists several chemical compounds frequently observed in prostate spectrums.

Table 6-1 Prostate Chemical Compounds

Chemical Compound	Chemical Shift (ppm)
Choline + Creatine/Citrate	2.0
Creatine (Cr)	3.0
Choline (Cho)	3.2
Citrate (Cit)	2.6
Lipid and Lactate	0.9 and 1.5

Scan Parameters

Scan Modes allows for four choices: two imaging modes (-1 and 0) and two spectroscopy modes (1 and 2).

- Scan Mode = -1 scans and displays an image of the slice centered within the voxel with narrow saturation (SAT) bands placed at the edges of the prescribed voxel. This image clearly shows the location of the voxel in reference to the entire slice and can be used to confirm the location of the voxel. Decrease the TR and TE to reduce the scan time.
- Scan Mode = 0 scans and displays an image of the voxel. This displays only the signal from the prescribed volume. Decrease the TR and TE to reduce the scan time.
- Scan Mode = 1 reconstructs the chemical shift images centered on the localizer images within the 3D volume. The spectra will be at the exact locations as the localizer images. When using the Chemical Shift Imaging (CSI) display tool, the overlay localizer images are the **exact** matches to the metabolic images. This is the default mode.
- Scan Mode = 2 acquires chemical shift images with the prescribed number of phase encoding steps, center spacing, and locations per slab. When displayed, the overlay localizer image is the **closest** match

to the metabolic image. If match is not exact, a message appears in the Functool command window stating "Not a perfect match."

NOTE: The total number of scans not used is displayed as "Unused for CSI."

Suppression Techniques

The Spectral Spatial RF (SSRF) imaging option can be used with PROSE. It provides better water, lipid, and slice selective suppression over the conventional BAnd Selective INversion Gradient dephasing (BASING) suppression techniques.

BASING is the original technique used for spectroscopy sequences. It consists of a 180° RF pulse applied in the frequency axis along with two crusher gradients with opposite polarity. Essentially what happens is the protons that are excited by the BASING 180° RF pulse are dephased and the spin echo is destroyed; protons not flipped are refocused by the bipolar gradients.

Spectral Spatial RF is another technique that can only be used with the PROSE spectroscopy sequence. It is activated by selecting it from the Imaging Options window. The SSRF technique simultaneously selects the fat, water and slice selective pulses. This replaces the original 180° BASING RF pulse. Since the pulses are applied simultaneously, suppression techniques are more robust and evenly applied. SSRF is the default suppression technique for PROSE. It is automatically turned on once the PROSE pulse sequence is selected. If you deselect this feature in the Imaging Options window the BASING suppression technique will be used in your spectroscopy sequence.

Spectroscopy Characteristics

Spectroscopy imaging characteristics are not like other imaging pulse sequences, since there are not many changeable imaging parameters or any actual anatomical images being produced. However there are several factors you should consider when using spectroscopy:

- The suppression level (Supp Lvl) percentage, shown on the Advisory Panel, should be between 95-99%. If the value is less than 95% run prescan again. If the value is still low you may need to reposition your voxel over more homogeneous anatomy.
- Homogeneity is more critical than water suppression to obtain a successful CSI acquisition. The line width should not be greater than 15.

If the line width is greater than 15, try one or more of the following suggestions:

- Make the voxel smaller.
- Move the voxel to avoid regions of large susceptibility change.
- Move the voxel to avoid anatomy known to cause line width problems.
- Move the voxel to avoid disease regions (hemorrhage) that are known to cause line width problems.
- Ten Very Selective Saturation (VSS) bands can be placed around or through the prescribed VOI. In the default operating mode, six VSS bands are placed around the Volume Of Interest (VOI). The four remaining VSS bands can be graphically placed on the PRESS ROI to suppress regions within the ROI. You may graphically prescribe more than four VSS bands, but this means that the six default VSS bands placed around the VOI must be deleted, not including the explicitly prescribed sat bands. The S/I bands are deleted first, followed by the A/P bands, and then the R/L default saturation bands.
- After a successful scan, chemical shift images that cover the frequency range from 4.30 to 0.49 ppm are drawn on a 512x512 image. The individual chemical shift images and the related spectra are visualized using the CSI display on the Browser.

Associated Imaging Options

There are several Imaging Options that can be used in conjunction with the PROSE pulse sequence. In Table 6-2 the Xs indicate the options available for use with the PROSE pulse sequence.

Table 6-2 PROSE Pulse Sequence Imaging Options

Imaging Options			
	None		Variable Bandwidth
	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel		Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer		Sequential
X	Cardiac Gating/Triggering		Respiratory Gating/Triggering

Imaging Options			
	Tailored RF		IR Prepared
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep	X	Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

Applications

PROSE is used to provide non-invasive acquisitions of high resolution images and spectral information about relative concentration of metabolites of the prostate gland to aid in the diagnosis of prostate diseases.

NOTE: Post-processing for the PROSE sequence is the same as for the 3D Focal Brain sequence.

How Do I...

This section provides the step-by-step instructions for performing a PROSE sequence. Specifically, it describes how to:

- Perform a PROSE Sequence
- Prescribe a PROSE Sequence

Decision Matrix

A decision matrix is used in this section to provide examples of what values could be selected for prescribing a particular sequence. The purpose of the decision matrix is to help you understand the trade-offs that occur when you change the values for a particular parameter and to provide a framework with which you may build your own unique protocol.

The example of protocols provide information on what could be used for these pulse sequences and are not to be considered recommendations by GE Medical Systems. For specific protocols, refer to the protocols on your system.

In addition to listing the information you need to select on the system, the “What You Select” column of the matrix uses two other conventions.

- N/A indicates that the imaging parameter is not applicable to the pulse sequence example.
- N/S indicates that the imaging parameter is not selectable in the pulse sequence example. The system automatically selects these imaging parameters.

Perform a PROSE Sequence

In Brief: Perform a PROSE Sequence

1. Acquire a valid 3 Plane Localizer of the prostate area.
2. Acquire an oblique axial localizer (if desired).
3. Click **[New Series]**.
4. Select **Coil > ATD-T III**.
5. Select **Plane > Axial**.
6. Select **Mode > MRS**.
7. Select **Grad Mode > Zoom**.
8. Select **Pulse Sequence > PROSE**.
9. Select **Imaging Options > EDR and Spectral Spacial RF**.
10. Click **[Accept]**.
11. Click **[User CVs Screen]**.
12. Enter your scan mode preference into the **Scan Mode** text box.
13. Enter the number of SAT bands in the **ROI edge sat mask** text box.
14. Enter the **Scanning Range** parameters in the correct order.
15. Click **[Graphic Rx]**.

This procedure is only for performing a 3D CSI spectroscopy scan from a valid localizer, not for reading the spectrum. A prerequisite for this data collection is the acquisition of one or more localizer images.

1. Acquire a valid 3 Plane Localizer of the prostate area.
 - ♦ PROSE is compatible with any scan plane.
 - ♦ Minimize the time between the localizer scan and the spectroscopy acquisition to decrease chances of patient movement and to ensure accurate position.
 2. Acquire an oblique axial localizer (if desired).
 - ♦ Only acquire an oblique axial plane localizer if you want to acquire an oblique axial plane PROSE sequence.
 3. Click **[New Series]**.
 4. Select **Coil > ATD-T III**.
 - ♦ ATD-T III is currently the Endorectal and Torso Phased Array coils connected with the ATD-T III connector.
- NOTE:** Refer to your Medrad Autotune Device (ADT) information for proper use and handling of this coil connector.
5. Select **Plane > Axial**.
 - ♦ Located in the **Imaging Parameters** area.
 6. Select **Mode > MRS**.
 - ♦ Spectroscopy sequences are only available in MRS mode.
 7. Select **Grad Mode > Zoom**.
 - ♦ Refer to the Gradient, Shim and Imaging Coils chapter for additional information on Gradient Modes.
 8. Select **Pulse Sequence > PROSE**.
 - ♦ Located in the **Imaging Parameters** area.
 9. Select **Imaging Options > EDR and Spectral Spacial RF**.
 - ♦ Refer to the Imaging Options chapter in Volume 4 for additional information on these options.

10. Click **[Accept]**.
 - ◆ This registers the imaging option into your current acquisition.
11. Click **[User CVs Screen]**.
 - ◆ Located in the **Additional Parameters** area.



User CVs Screen

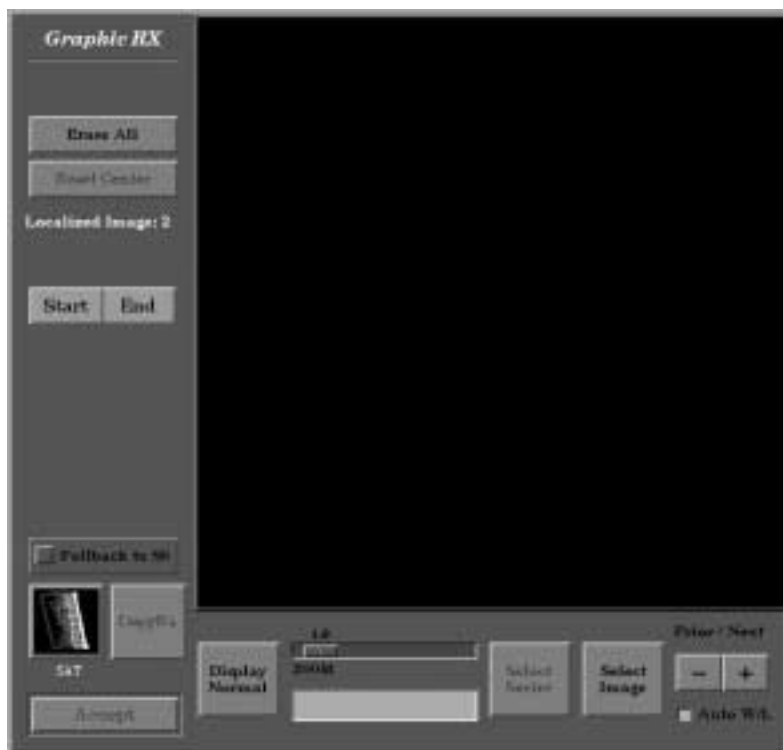
12. Enter your scan mode preference into the **Scan Mode** text box.
 - ◆ Refer to the User CVs section of this chapter for explanation of scan modes.
- NOTE:** The **Temp** value defaults to 37.00. This should **not** be changed, this is the optimal temperature setting for human spectroscopy.
13. Enter the number of SAT bands in the **ROI edge sat mask** text box.
 - ◆ Up to six additional SAT bands can be prescribed.

In Brief: Perform a PROSE Sequence cont.

16. Click **[+]** or **[-]** until the desired image with which you would like to start your voxel coverage appears in the **Graphic Rx** window.
17. Click **[Start]**.
18. Click **[+]** or **[-]** until the desired image with which you would like to end your voxel coverage appears in the **Graphic Rx** window.
19. Click **[End]**.
20. Click **[Accept]**.
21. Enter timing parameters in the **Scan Timing** area.
22. Enter both the frequency and phase matrices.
23. Enter in an acceptable NEX in the **NEX** text box.
24. Turn **Autoshim** on.
25. Click **[Save Series]**.
26. Click **[Prepare to Scan]**.
27. Click **[Auto Prescan]**.
28. Check the advisory area for line widths and water suppression levels.
29. Click **[Scan]**.

NOTE: Refer to the Clinical Spectroscopy Pulse Sequences chapter in the Signa® MR/™ with Signa Select™ (ASP2) Learning and Reference Guide, for additional information on saturation bands.

14. Enter the **Scanning Range** parameters in the correct order.
 - ◆ The parameters must be entered in the system in the order provided below.
 - a) Locs per Slab: enter 8 or greater.
 - b) Voxel Thickness: enter in your desired thickness.
15. Click [**Graphic Rx**].
 - ◆ Located in the **Additional Parameters** area.



Graphic Rx Image


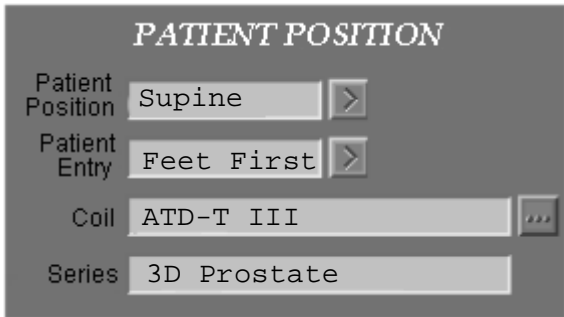
16. Click [**+**] or [**-**] until the desired image with which you would like to start your voxel coverage appears in the **Graphic Rx** window.
17. Click [**Start**].
 - ◆ First slice of your voxel coverage.

18. Click **[+]** or **[-]** until the desired image with which you would like to end your voxel coverage appears in the **Graphic Rx** window.
19. Click **[End]**.
 - ◆ Last slice of your voxel coverage.
20. Click **[Accept]**.
 - ◆ Registers both the start and end locations into the **Scanning Range** area.
21. Enter timing parameters in the **Scan Timing** area.
 - ◆ Suggested TE is 130 and TR is 1000 ms.
22. Enter both the frequency and phase matrices.
 - ◆ Located in the **Acquisition Timing** area.
 - ◆ Acceptable values are even numbers between 8-16.
23. Enter in an acceptable NEX in the **NEX** text box.
 - ◆ Located in the **Acquisition Timing** area.
24. Turn **Autoshim** on.
 - ◆ Recommended that Autoshim is on for spectroscopy sequences.
25. Click **[Save Series]**.
26. Click **[Prepare to Scan]**.
 - ◆ Downloads PROSE acquisition.
27. Click **[Auto Prescan]**.
28. Check the advisory area for line widths and water suppression levels.
 - ◆ Line Width: 12 to 15 is an acceptable range for Single Voxel acquisitions. If higher, rerun the prescription prescan. If a decrease is still not seen you may want to reposition your voxel to obtain a better shim.
 - ◆ Water Suppression level: An acceptable range is 95% or above. If below, rerun the prescription prescan. If an increase is still not seen you may want to reposition your voxel to obtain a better shim.
29. Click **[Scan]**.
 - ◆ Initiates your PROSE acquisition.

Prescribe a PROSE Pulse Sequence

PROSE is three dimensional multi voxel spectroscopy sequence used to produce spectra of the human prostate gland area. This decision matrix (Table 6-3) is only for prescribing a PROSE sequence.

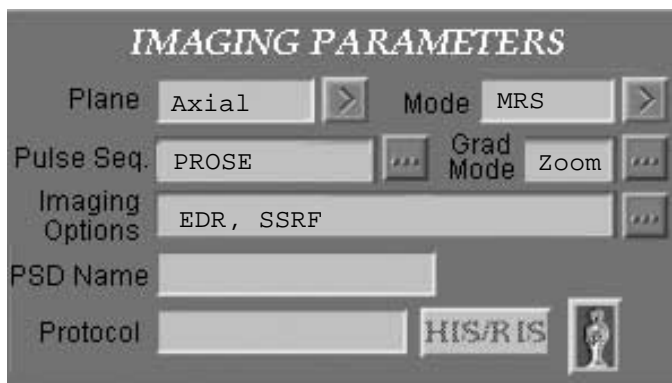
Table 6-3 PROSE pulse sequence protocol example.

PROSE Protocol Example		
What you select		Selection Notes
SCAN DESKTOP screen		
		
Rx Manager area	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	If the Patient Protocol screen becomes active, Patient Position allows you to begin prescribing your new series.
PATIENT POSITION		
		
Patient Position	Supine	3D PROSE is used in prostate scanning, so the patient position and entry selections reflect that.
Patient Entry	Feet First	
Coil	ATD-T III	Select the name given for the ATD-T III connector. This allows you to use both the Torso PA and the Endorectal coil simultaneously.
Series	Type in a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and imaging options.

PROSE Protocol Example

What you select	Selection Notes
-----------------	-----------------

IMAGING PARAMETERS



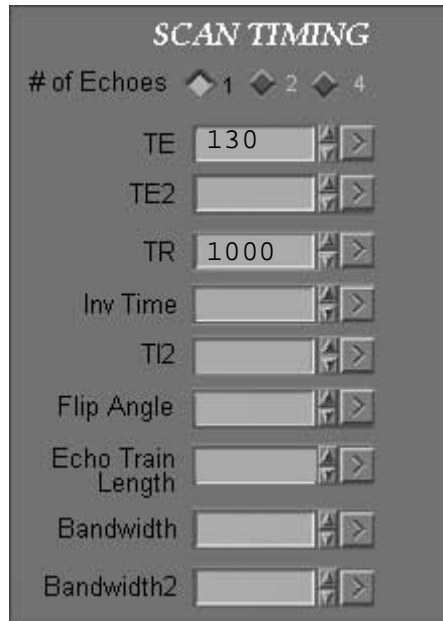
Plane	Axial	PROSE is compatible with any scan plane including oblique and 3-Plane localizers; select the same plane as the localizer scan plane. This is different from the normal prescription process. Typically, an axial is prescribed from a sagittal or coronal. With probe, an axial must be prescribed from an axial localizer.
Mode	MRS	MRS is the only mode that allows spectroscopy imaging.
Grad Mode	Zoom	PROSE is compatible with either gradient mode option.
Pulse Seq	PROSE	Select PROSE.
Imaging Options	EDR, SSRF	Use Extended Dynamic Range on all spectroscopy scans. Click [Accept] to register the selections.

PROSE Protocol Example

What you select

Selection Notes

SCAN TIMING

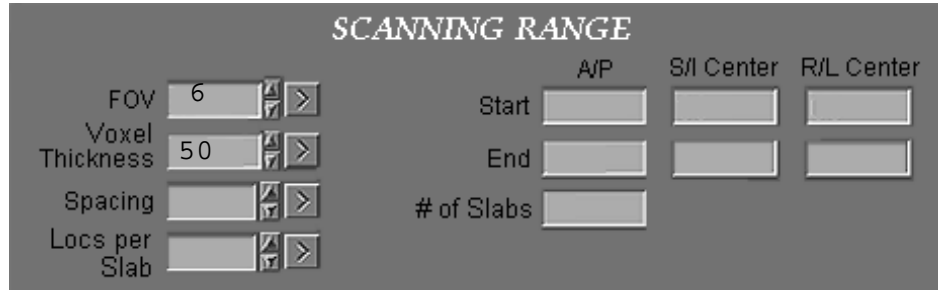


# of echoes	1	Only 1 echo is allowed.
TE	130	This is the optimal TE value for PROSE acquisition.
TE2	N/A	
TR	1000	If the scan mode = 1, select a typical TR of 1000 ms. A longer TR results in increased SNR at the expense of increased scan time. If the scan mode = 0, (voxel image) select the shortest allowed values for TR.
TI	N/A	
Flip Angle	N/A	
Echo Train Length	N/A	
Bandwidth	N/S	The Receiver Bandwidth is automatically selected for spectroscopy scans and cannot be programmed.
Bandwidth 2	N/A	

PROSE Protocol Example

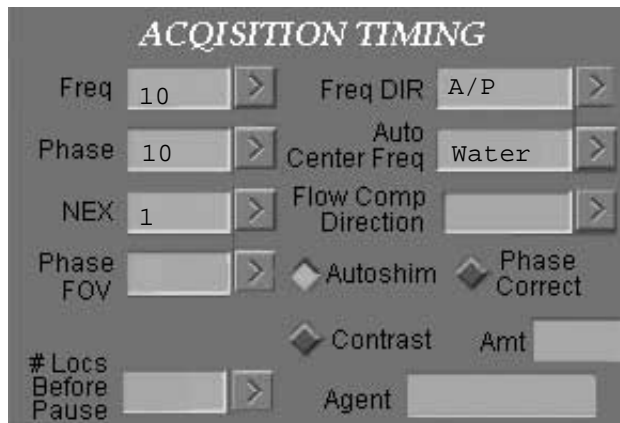
What you select	Selection Notes
-----------------	-----------------

SCANNING RANGE



FOV	6-12	Choose FOV that is optimal for covering the prostate gland.
Voxel Thickness	50	Choose a voxel thickness large enough to cover the anatomy or pathology. The lower limit is 3 mm and the upper limit is 100 mm.
Spacing	Choose 1st option from menu.	The first option is optimum, the system automatically calculates this based on your chosen FOV, voxel thickness and matrix size.
Locs per Slab	8-16	Choose the number of locations per slab. Acceptable values are even numbers from 8 to 16.

ACQUISITION TIMING



Freq	10	Acceptable matrix values are even numbers 8 to 16. As the matrix value increases, the spatial resolution increases and the scan time increases.
Phase	10	
NEX	1	As the NEX value increases, the SNR increases and the scan time increases.
Freq DIR	A/P	Select the default value.
Auto Center Freq	Water	Water is generally the frequency selected.
Flow Comp DIR	N/A	

PROSE Protocol Example

What you select		Selection Notes
Autoshim	On	Select Autoshim to make the volume of interest as homogeneous as possible.
Phase Correct	N/A	

ADDITIONAL PARAMETERS

GRAPHIC Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
	Click the image to display the voxel.	Position the volume to cover anatomy of interest. Click and drag the tick marks to re-size the volume. Click and drag on the center of the volume to re-position the volume.
Reset Center	[Reset Center] (if necessary)	Allows you to re-establish the voxel center on a different localized slice. Click after the new desired center is selected.
Copy Rx	[Copy Rx] (optional)	If you had previously graphically prescribed a series with the same plane, FOV, and slice thickness, the prescription can be copied to the exact locations of the prior series.
Erase	[Erase] (if necessary)	Eliminates the voxel volume from the screen and start over.
Accept	[Accept]	Confirms the cursor position and close Graphic Rx.

ADDITIONAL PARAMETERS

User CVs

Scan Mode	1	Select a scan mode of 0 for the voxel imaging mode or 1 for the spectroscopy acquisition mode.
Total number of Scans	N/A	
ROI edge sat mask	7	Enables the placement of VSS bands around the VOI. Enter 7, this initiates R/L, A/P and S/I SAT band placement.

Series Control

Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
-------------	----------------------	---

Rx Manager

Prepare to Scan	[Prepare to Scan]	Downloads the series.
-----------------	--------------------------	-----------------------

Scan Operations

PROSE Protocol Example		
What you select		Selection Notes
Auto Prescan	[Auto Prescan]	Auto Prescan is performed and the system is readied for data acquisition and completes the following sets: TG, RG and CF. Auto Prescan can fail if the voxel volume is comprised of inhomogeneous anatomy. If Auto Prescan fails, it is most likely due to the placement of the voxel volume. If the FWHM value is larger than 6-7 Hz for a 8 cc volume, try repositioning the voxel volume to a more homogeneous area of anatomy and Auto Prescan again.
Scan	[Scan]	Initiates the acquisition.

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Chapter 7

2D FIESTA Pulse Sequence

Introduction

The Fast Imaging Employing S_Teady-state Acquisition (FIESTA) is a fully balanced steady-state coherent imaging pulse sequence designed to produce high signal-to-noise ratio (SNR) images at very short sequence times (TRs).

This chapter explains the pulsing components and timing factors directly related to the 2D FIESTA imaging pulse sequence. It also explains the concepts and the step-by-step instructions to help you learn how to:

- Optimize 2D FIESTA Images
- Prescribe a 2D FIESTA Sequence

In addition, this chapter answers the following questions:

1. What is FIESTA?
2. When would I use a 2D FIESTA pulse sequence?
3. What are the imaging characteristics of a 2D FIESTA pulse sequence?
4. Which imaging options can be used with a 2D FIESTA pulse sequence?
5. What are some applications for the 2D FIESTA sequence?

What Do I Need to Know About...

This section presents the concepts necessary to understand imaging with the 2D FIESTA pulse sequence. Specifically, you need to understand the following concepts:

- 2D FIESTA Basics
- Imaging Effects
- Image Characteristics
- Associated Imaging Options
- Applications

2D FIESTA Basics

The Fast Imaging Employing STeady-state Acquisition (FIESTA) sequence is a fully balanced steady-state coherent imaging pulse sequence designed to produce high SNR images at very short TRs. The pulse sequence uses fully balanced gradients to re-phase the transverse magnetization at the end of each TR interval. For very short TR sequences, the resulting signal intensity is independent of TR and related to (T_2/T_1) . More importantly, the short TRs are essential to maintain spin phase coherence. Phase coherence is required to maintain coherent transverse magnetization and eliminate artifacts generated by magnetic susceptibility induced phase shifts. Thus, the advantages of FIESTA can only be realized with very short TR where $(TR \ll T_2)$ and $(TR \ll 1/b)$ where b is the local frequency shift caused by inhomogeneity.

NOTE: \ll indicates “much less than”.

Tissue contrast is generated based on the ratio of the spin-spin relaxation time (T_2) and the spin-lattice relaxation time (T_1). Hence, the pulse sequence accentuates the contrast of spins with high T_2/T_1 ratios (such as cerebral-spinal fluid, water, and fat) while suppressing signal from tissues with low T_2/T_1 ratios (such as muscle and myocardium).

2D FIESTA is a fast-ECG-gated, segmented K-space acquisition. The sequence combines both high temporal resolution with excellent image contrast and can be used for whole body imaging. 2D FIESTA can be used in clinical applications that benefit from the differentiation of contrast between tissues of low T_2/T_1 ratios (low signal intensity) and high T_2/T_1 ratios (high signal intensity). This type of acquisition sequence can be useful for imaging structures in motion such as the heart.

The 2D FIESTA technique uses balanced gradients, which are designed to maintain phase coherence of the transverse magnetization at each radio frequency (RF) excitation. Most other fast scan techniques use phase spoiling to eliminate phase coherence.

Imaging Effects

The sequence parameters have different effects that contribute to the 2D FIESTA images. Table 7-1 summarizes the imaging effects relating to 2D FIESTA and is provided to help you understand the trade-offs that occur when you change the values for a particular parameter.

Table 7-1 Imaging Effects with 2D FIESTA

Parameters	Contrast (T ₂ /T _s)	Temporal Resolution	Spatial Resolution	SNR	Scan Time	Artifacts
TR ↓	↑	↑	N/A	↑	↓	↓
TE ↓	↑	N/A	N/A	↑	↓	↓
Flip Angle ↑	↑	N/A	N/A	↑	N/A	N/A
RBw ↑	↑	↑	N/A	↓	↓	↓
VPS ↑	N/A	↑	N/A	N/A	↓	↑
Matrix ↑	N/A	N/A	↑	↓	↑	N/A
Slice Thickness ↓	N/A	N/A	↑	↓	N/A	N/A
FOV ↓	N/A	N/A	↑	↓	N/A	*

NOTE: *There is always a direct correlation between FOV and artifact. In certain instances, with anatomical size and FOV, some artifact can occur (wrap). In most other circumstances, there will not be a correlation.

Image Characteristics

2D FIESTA sequences are capable of producing high signal to noise images with enhanced contrast and temporal resolution. Water and fat contrast is accentuated, while muscle and myocardial tissues are suppressed.

There are several benefits of 2D FIESTA:

- High signal-to-noise images
- Excellent contrast between soft tissues and fluids
- Reduced repetition times, which minimizes motion artifacts
- Inherent flow compensation, which minimizes artifacts due to blood flow

Figure 7-1 Image of 2D FIESTA FastCINE. Note the increased SNR over the standard FastCINE acquisition shown on the left.

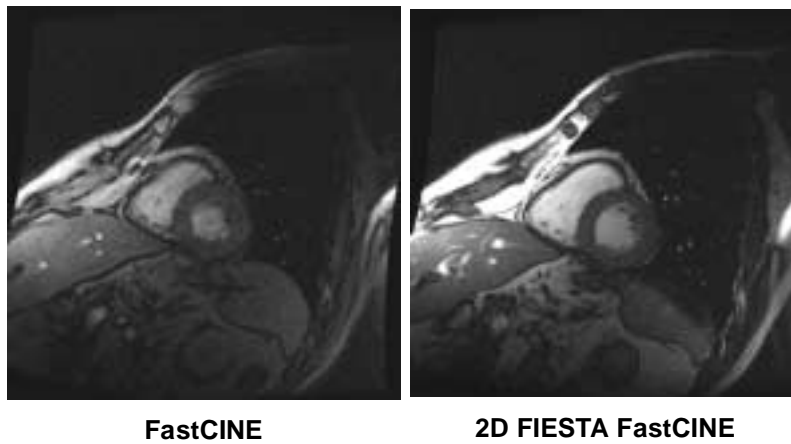


Table 7-2 Timing differences between the standard FastCINE sequence and the 2D FIESTA FastCINE sequence

Oblique Short Axis FOV = 36 Slice Thickness = 7 mm Matrix = 256x192		FastCINE	2D FIESTA FastCINE
		TR	7.3 ms
	TE	2.7 ms	1.8 ms

There are several factors you should consider when using 2D FIESTA:

- The Receive Bandwidth (RBw) is fixed at 125 kHz
- The TE is fixed at the minimum full value
- The smallest FOV with a 384 frequency matrix is 24 cm and 22 cm with a frequency matrix of 256
- A 512 frequency matrix is not supported by 2D FIESTA

Associated Imaging Options

Imaging Options provide image processing or filters for enhancing anatomical features or reducing noise. In Table 7-3, the Xs indicate the imaging options available for use with the 2D FIESTA pulse sequence.

Table 7-3 2D FIESTA Pulse Sequence Imaging Options

Imaging Options			
	None	X	Variable Bandwidth
	Flow Compensation	X	No Phase Wrap
	POMP	X	Extended Dynamic Range
X	Square Pixel	X	Image Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer	X	Sequential
X	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF		IR Prepared
	DE Prepared		Multi Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

Applications

2D FIESTA imaging can be used in clinical applications that benefit from the differentiation of contrast between tissues of low T2/T1 ratios (low signal intensity like the myocardium) and high T2/T1 ratios (high signal intensity like blood). This type of acquisition sequence can be useful for imaging, but not limited to, structures in motion such as the heart, which needs clear delineation between the blood and the myocardium. The improved blood

pool myocardium contrast allows for better delineation of the myocardial boundaries and hence expedites the determination of the ventricular volumes at end-systole and end-diastole.

How Do I...

This section provides the step-by-step instructions for prescribing a 2D FIESTA imaging pulse sequence. Specifically, it describes how to:

- Prescribe a 2D FIESTA Sequence

This section also provides the following 2D FIESTA images and an example protocol.

- Cardiac Short or Long Axis

Decision Matrix

A decision matrix is used in this section to provide examples of what values could be selected for prescribing a particular sequence. The purpose of the decision matrix is to help you understand the trade-offs that occur when you change the values for a particular parameter and to provide a framework with which you may build your own unique protocol.

The example protocols provide information on what could be used for these pulse sequences and are not to be considered recommendations by GE Medical Systems. For specific protocols, refer to the protocols on your system.

In addition to listing the information you need to select on the system, the “What You Select” column of the matrix uses two other conventions.

- N/A indicates that the imaging parameter is not applicable to the pulse sequence example.
- N/S indicates that the imaging parameter is not selectable in the pulse sequence example. The system automatically selects these imaging parameters.



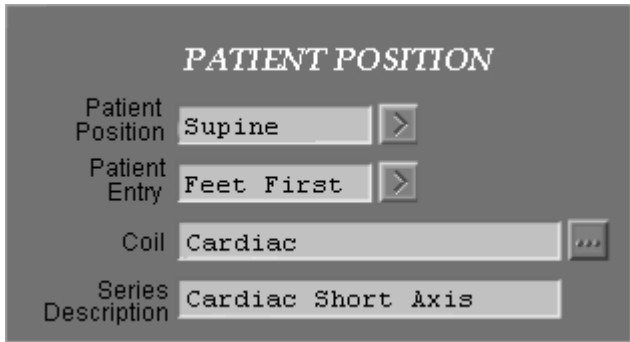
CAUTION: Provide all patients with ear protection prior to any scan to help avoid possible hearing impairment. Acoustic noise levels can exceed 99 dbA in the magnet bore.

Prescribe a 2D FIESTA Sequence

The 2D FIESTA sequence is useful for imaging structures in motion such as the heart, which needs clear delineation between the blood and the myocardium. The improved blood pool myocardium contrast allows for better delineation of the myocardial boundaries and hence expedites the determination of the ventricular volumes at end-systole and end-diastole.

The decision matrix (Table 7-4) is only for prescribing a 2D FIESTA scan. The following example protocol is for prescribing a short axis cardiac scan for a TwinSpeed™ or an EchoSpeed™ system.

Table 7-4 2D FIESTA Protocol Example (Short Axis Cardiac)

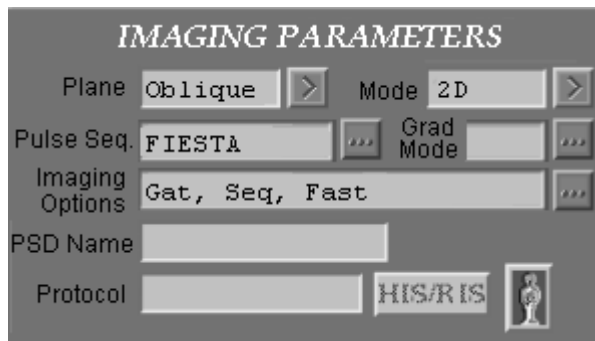
2D FIESTA Protocol Example		
What You Select		Selection Notes
Scan Rx Desktop		
Scan Rx	Acquire a localizer series	Allows Graphic Rx to become available so you can prescribe slices graphically on the localized image.
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol window becomes active.
Patient Position		
		
Patient Position	Supine	Although compatible with any patient position and entry, supine and feet first are recommended. This ensures accurate cardiac gating/trigging and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	
Coil	Phased Array > Cardiac	Use a coil that produces the optimum coverage and SNR.
Series Description	Enter a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

2D FIESTA Protocol Example

What You Select

Selection Notes

Imaging Parameters



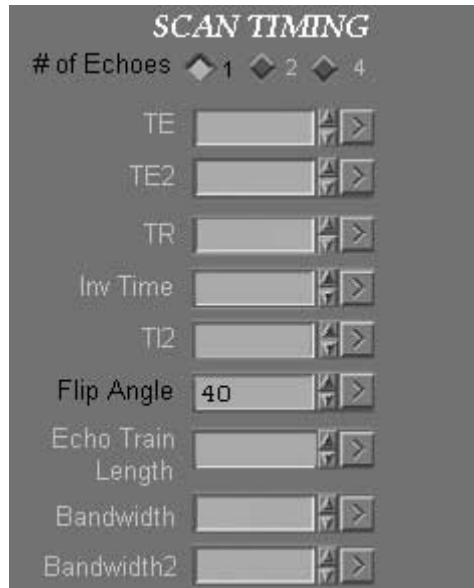
Plane	Oblique	Compatible with any scan plane. Select the plane that best meets your clinical need. For cardiac short or long axis imaging, select oblique for proper angle through the heart.
Mode	2D	Prescribes a two-dimensional sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	FIESTA	Prescribes a FIESTA pulse sequence.
Imaging Options	Cardiac Gating Triggering and Sequential	Cardiac Gating/Triggering and Sequential are automatically selected and cannot be turned off. Sequential acquires one slice at a time and multiple cardiac phases.
PSD Name	N/A	
Protocol	N/A	

2D FIESTA Protocol Example

What You Select

Selection Notes

Scan Timing



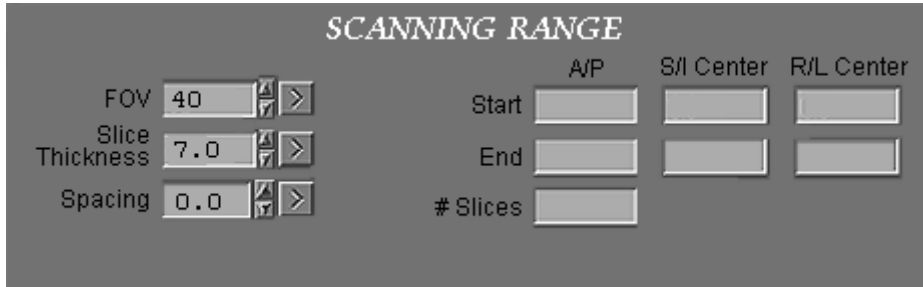
# of echoes	N/S	One echo is selected automatically.
TE	N/S	The TE default is minimum full.
TE2	N/A	
TR	N/S	The minimum TR is selected automatically. TR is a function of the patients heart rate and should be approximately 5 to 20 seconds.
Inv Time	N/A	
TI2	N/A	
Flip Angle	40	The typical flip angle value is 40° to 45°.
Echo Train Length	N/A	
Bandwidth	N/S	The RBw default is 125 kHz.
Bandwidth2	N/A	

2D FIESTA Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	40	Select a FOV that covers the anatomy of interest, about 40 cm for the chest. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	7.0	The typical slice thickness value for the heart is 7 to 8 cm. Thin slices produce increased resolution and decreased SNR.
Spacing	Enter 0.0 in the text box.	Zero spacing is allowed. Slices are acquired sequentially and cross-talk is not a problem.
Start, End Locations		The start and end locations are programmed from the Graphic Rx program after the slices are prescribed.
# Slices		Sequential scan ones slice per acquisition. The number of slices indicates the number of acquisitions prescribed.

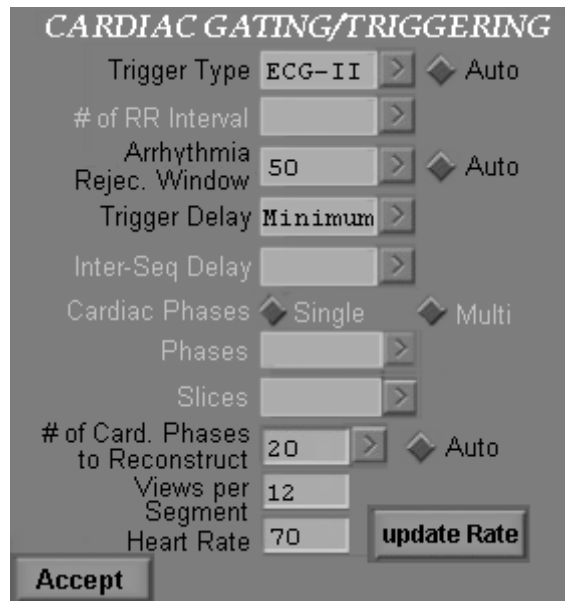
Acquisition Timing



Freq	Enter 224 in text box.	Increasing the frequency matrix produces increased resolution, decreased SNR, and decreased number of slices.
Phase	Enter 224 in text box.	Phase controls scan time and may control resolution.

2D FIESTA Protocol Example		
What You Select		Selection Notes
NEX	1	One NEX for sufficient SNR and a reasonable scan time.
Phase FOV	0.75	Select a phase FOV to prevent wrapping of anatomy. Choices are 1.0, 0.75, and 0.5. Reducing the phase matrix decreases scan time, FOV in the phase direction, and SNR (slightly).
Freq DIR	S/I	The direction displayed is the default frequency direction which is typically the long axis of the image. Leave the frequency direction unswapped.
Auto Center Freq	Water	The CF peak that will be set during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Autoshim can improve image quality and is recommended for this sequence.
Phase Correct	Off	Provides no additional benefits and increases prescan time.
# of Locs Before Pause	1	After you prescribe the slices, return to this screen and prescribe an automatic pause in the scan at predetermined points for breath-hold studies.

Additional Parameters - Gating/Triggering

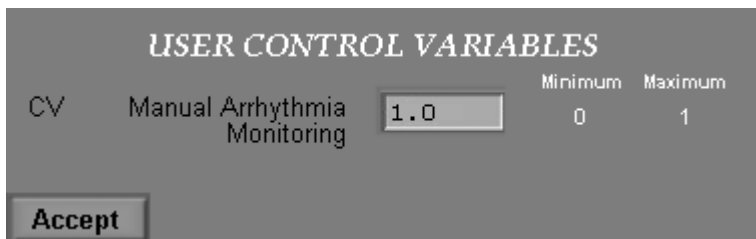


Trigger Type	Select the best lead.	When ECG gating, use the lead that provides the best signal.
# of R-R Interval	N/A	
Arrhythmia Rejec. Window	50	Values around 50% are most commonly used to allow a reasonable latitude. If the patient's heart rate is irregular, increase this value and the TW, then the time available to collect data will decrease.

2D FIESTA Protocol Example

What You Select		Selection Notes
Trigger Delay	Minimum	The most minimum TD is desired to cover the full R-R Interval.
Inter-Seq. Delay	N/A	
Cardiac Phases	N/A	
# of Cardiac Phases to Reconstruct	Enter 20 in the text box.	Sets the number of cardiac phases to be reconstructed.
Views per Segment	12	The typical range of values is 12 to 20 VPS. Heart Rate = 50, select 20 VPS. Heart Rate = 70, select 12 VPS.
Heart Rate	[update Rate]	Lets the system obtain an automatic reading of the current heart rate. Updates the rate prior to beginning the scan.
Accept	[Accept]	Confirms the selected values and closes Gating/Triggering Additional Parameter screen.

Additional Parameters - User CVs



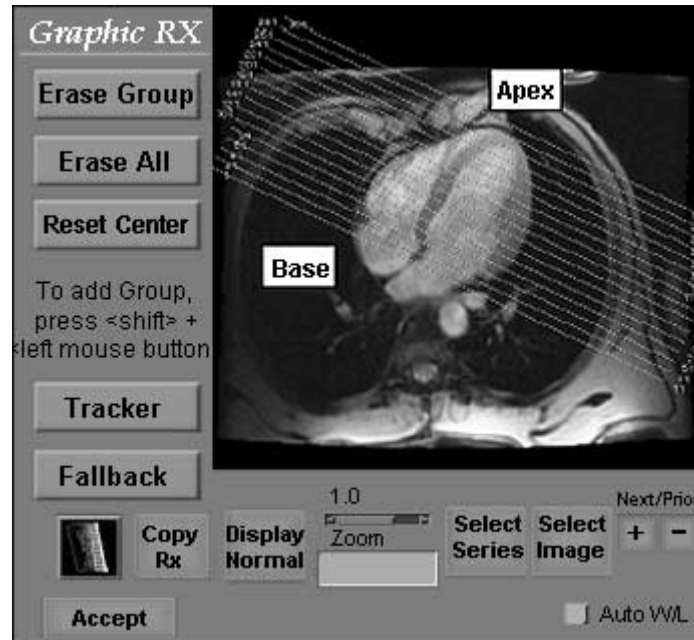
Manual Arrhythmia Monitoring	1.0	Manually monitors arrhythmias. When Auto Arrhythmia Monitoring is on (0), too many triggers are detected outside the TW resulting in an aborted scan.
Accept	[Accept]	Confirms selection of User CV and closes the screen.

2D FIESTA Protocol Example

What You Select

Selection Notes

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Prescribe slices from the cardiac base to the apex for graphic prescription. Select the adjustment handles to angle, draw, and remove slices. Position the slices to cover anatomy of interest and view the Advisory Panel to note the maximum number of slices per acquisition and the number of acquisitions you are prescribing. The scan time increases as the number of acquisitions increase.
Copy Rx	[Copy Rx] (optional)	If you had previously graphically prescribed a series with the same plane, FOV, and slice thickness, the prescription can be copied to the exact locations of the prior series.
Erase All	[Erase All] (if necessary)	Eliminates the graphic prescription from the screen and allows you to start over.
Reset Center	[Reset Center] (if necessary)	Re-establishes the FOV center on a different localized slice.
Accept	[Accept]	Confirms the cursor position and closes Graphic Rx.
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.

2D FIESTA Protocol Example		
What You Select		Selection Notes
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Prep Scan	[Prep Scan]	Performs Auto Prescan and readies the system for data acquisition. Select for breath-hold acquisitions.
Scan	[Scan]	Initiates the acquisition. Instruct the patient to hold his/her breath as long as possible, until the scan stops, if able.

2D Cardiac Short or Long Axis

A Cardiac short or long axis scan can be acquired with a 2D FIESTA pulse sequence to image the heart. This sequence provides improved blood-pool myocardium contrast for better delineation of the myocardial boundaries. Figure 7-2 shows long and short axis images of the heart acquired with 2D FIESTA sequences. Table 7-5 gives you a brief look at an example protocol. The parameters may vary depending on your needs.

Figure 7-2 2D FIESTA Acquisitions

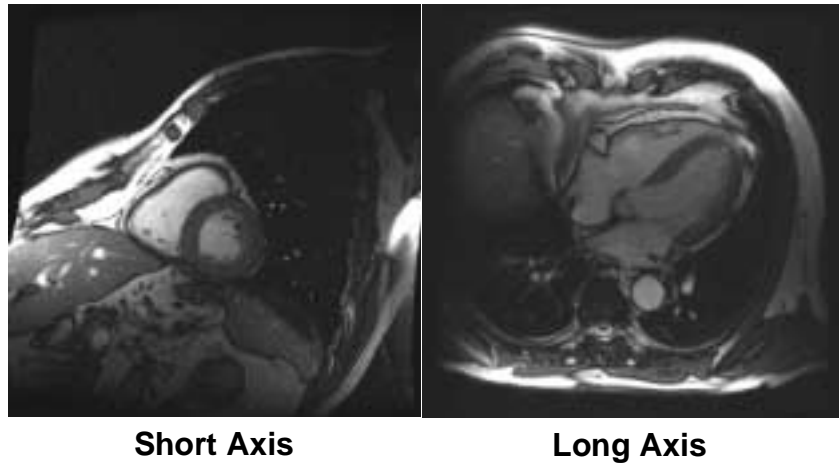


Table 7-5 2D FIESTA Cardiac Protocol Example

Plane	Mode	Pulse Sequence	PSD Name	TE	TR	Flip Angle	RBw	FOV	Slice Thickness	Slice Spacing
Oblique	2D	FIESTA	N/A	Min Full	N/A	40 to 45	125	~40	7 to 8	0.0
Matrix	NEX	Phase FOV	Frequency Direction	Center Frequency	Auto Shim	Phase Correct	Imaging Options		Sat Pulses	
224x224	1	0.75	Unswapped	Water	On	Off	Cardiac Gating/Trig, Sequential		None	
Trigger Type	ARW	TD	VPS	Phases	User CVs	Time		Comments		
Best Lead	50	Min	12 to 20 HR 50=20 HR 70=12	20	Manual Arrhythmia Monitoring = 1	A function of patients heart rate. Approx 5 to 20 seconds.		Cardiac coil recommended		

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Chapter 8

Myocardial Assessment Pulse Sequences

Introduction

Myocardial Assessment is an imaging technique used to evaluate myocardial viability. It consists of a three sequence protocol used to demonstrate heart function, myocardial perfusion, and overall viability of the myocardium.

This chapter explains the background of the Myocardial Assessment protocol and the sequences used in imaging myocardial assessment. This chapter also explains the concepts of each sequence and provides the step-by-step instructions to help you learn how to:

- Prescribe the Wall Motion Sequence
- Prescribe the First Pass Sequence
- Prescribe the Delayed Enhancement Sequence

In addition, this chapter answers the following questions:

1. What makes up a Myocardial Assessment protocol?
2. Why do I need a Wall Motion Sequence?
3. What is tagging?
4. How do I know what VPS to use?
5. Which imaging mode supports the First Pass Sequence?

What Do I Need to Know About...

This section presents the concepts necessary to understand the background of the Myocardial Assessment Imaging protocol. Specifically, you need to understand the following concepts:

- Myocardial Assessment Imaging Basics
- Wall Motion Sequence
 - Tagging
 - Views Per Segment Guide
- First Pass Sequence
- Delayed Enhancement Sequence

Myocardial Assessment Imaging Basics

Myocardial Assessment is an imaging technique used to evaluate myocardial viability. The Myocardial Assessment imaging protocol is typically made up of three pulse sequences. All three sequences work together to evaluate the left ventricular (LV) myocardium.

The three sequence protocol includes:

1. The Wall Motion Sequence acquired with a gated FastCINE Gradient Echo (GRE) pulse sequence if tagged or a FastCine Spoiled Gradient Echo (SPGR) if no tags are used.
2. The First Pass Sequence using a gated Fast Gradient Echo with echo train readout (FGRE-Echo Train or FGRET) technique.
3. The Delayed Enhancement Imaging Sequence using an Inversion Recovery Prepped (IR Prep) Gated Fast Gradient Echo (FGRE) technique.

The Wall Motion Sequence demonstrates functional and anatomical information of the heart. The First Pass Sequence demonstrates myocardial perfusion. The third sequence, Delayed Enhancement, is used to aid in determining what tissue is viable (alive) or non-viable (dead or infarcted). The Delayed Enhancement sequence can be used alone; however, the first two sequences in the Myocardial Assessment protocol give additional clinical information concerning the heart's functional and anatomical status, as well as the perfusion abilities of the myocardium.

Wall Motion Sequence

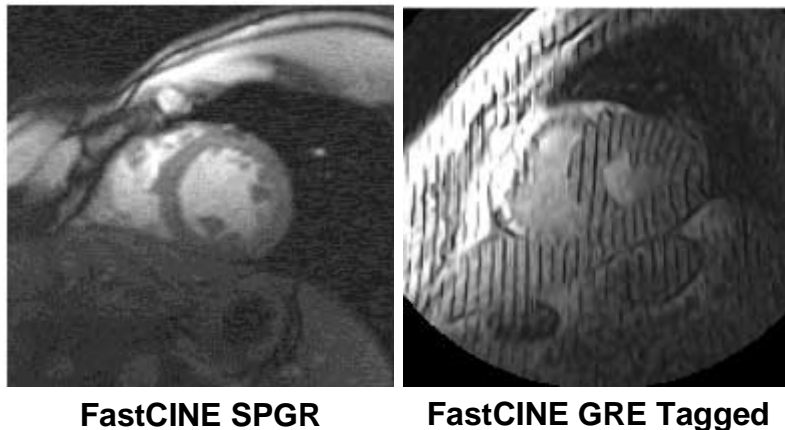
The Wall Motion Sequence demonstrates functional and anatomical information of the heart. This sequence should be acquired first to allow assessment of the contractile function of the ventricular wall. This also allows evaluation for any abnormal function resulting from infarcted tissue in the myocardium. Tagging is sometimes used to better visualize contractile function. The pulse sequence used is a cardiac gated FastCINE GRE if tagged or a FastCINE SPGR if no tags are used (Figure 3-1). FastCINE is a sequence that uses a combination of FastCard and CINE features to enable data acquisition throughout the entire cardiac cycle.

NOTE: For additional information on the FastCINE pulse sequence, refer to your Pulse Sequence Learning and Reference Guide.

Tagging is the application of spatial SAT pulses over the anatomy of interest to obtain cardiac images sensitive to tissue motion. The spatial SAT pulse is applied inside the FOV over the entire range. The tagging sequence is applied once per R-R Interval, before data acquisition begins, and

immediately following the R-Wave ECG trigger. There are two tag selections: stripes (diagonal lines) or a grid pattern. Figure 8-1 demonstrates the Wall Motion Sequence acquired with a FastCINE SPGR without tags and FastCINE GRE with the stripe tag selection.

Figure 8-1 Images acquired with the Wall Motion Sequence



The tag pixel spacing is defaulted to a value of seven pixels. The minimum spacing allowed is two pixels. The frequency matrix divided by two ($XRES \div 2$) determines the maximum setting.

Views Per Segment Guide

Table 8-1 is a guide to help you determine the Views per Segment (VPS) for images with multiple phases. This table is based on the patient’s heart rate for optimal temporal resolution and best image quality.

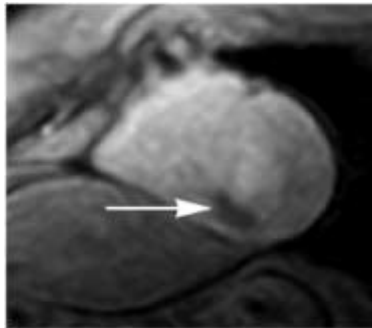
Table 8-1 Views Per Segment Guide

Heart Rate (BPM)	Views Per Segment
≤ 60	8
61 - 95	6
96 - 125	4
126 - 155	2
> 156	1

First Pass Sequence

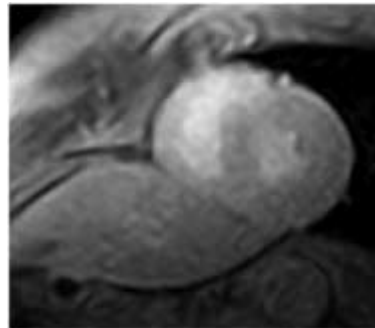
The First Pass Sequence demonstrates myocardial perfusion. The main purpose of this sequence is to aid in the diagnosis of diseased myocardium versus healthy myocardium. On the First Pass images, we are looking for filling defects (Figure 8-2) or regions of decreased signal. The sequence is a cardiac gated FGRET.

Figure 8-2 Images acquired with an FGRET sequence. Note the filling defect is only noticeable on the image that was acquired under stressed conditions.



FGRET

Representing a defect under stressed conditions.



FGRET

No defect under rest conditions.

In the FGRET pulse sequence, a saturation pre-pulse may be applied (IR Prep) for each slice. The Multi-slice acquisition is typically repeated for 40 to 60 heartbeats with a complete image of each slice being generated every heartbeat. To acquire in this mode, Multi Phase must be selected from the imaging options. To allow the highest temporal resolution, while applying sufficiently long inversion time to allow T1 weighting, the IR pre-pulse for the ensuing imaging plane is applied one slice ahead. Imaging occurs continually for the prescribed number of slices (8 slices with 80 BPM) across two heartbeats or 2 R-R Intervals.

NOTE: Refer to the chapter FGRET Pulse Sequences, in this guide, for additional information.

There are several factors you should consider when using the First Pass Sequence:

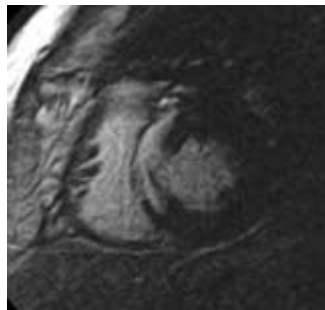
- Prescribe the maximum number of slice locations allowed per R-R Interval to prevent degradation of the first slice images acquired in the sequence.
- In the FGRET with Multi Phase (FGRET-MP) and IR Prep sequence, the pre-pulse is not applied to the first slice location, therefore, the image contrast for that slice differs from the remaining slices.

Delayed Enhancement Sequence

The Delayed Enhancement Sequence is the last of the three sequences in the Myocardial Assessment protocol. It is acquired by an IR Prep Gated Fast GRE technique and acquires images whose appearance is determined by the T1 relaxation time of the tissues. By using a fast gradient recalled echo segment with an inversion recovery RF pulse, various tissues can be suppressed or enhanced. The IR prep pulse in this sequence is a non-selective pulse, which means that it does not just excite the slice, but excites everything in the body coil. This is useful because the non-selective IR prep pulse suppresses myocardium and the blood as it enters the slice, nulling their signal.

The Delayed Enhancement Sequence also aids in evaluating the viability of the myocardium. This sequence assists in determining what tissue is capable of living or capable of working, functioning, or developing.

Figure 8-3 Delayed Enhancement image acquired with Fast GRE



Fast GRE

Recommendations for delay times and scan planes and are as follows:

- 5 minute short axis
- 10 minute short axis
- 15 minute long axis



WARNING: Do not use the Signa gating system cardiac waveforms for physiological monitoring. The patient's condition may not be reflected, resulting in improper emergency medical treatment.

How Do I...

This section provides the step-by-step instructions for following the Myocardial Assessment protocol and prescribing the imaging pulse sequences. All three of the following sequences work together to evaluate the LV myocardium. Specifically, this section describes how to:

- Prescribe the Wall Motion Sequence
- Prescribe the First Pass Sequence
- Prescribe the Delayed Enhancement Sequence

Decision Matrix

A decision matrix is used in this section to provide examples of what values could be selected for prescribing a particular sequence. The purpose of the decision matrix is to help you understand the trade-offs that occur when you change the values for a particular parameter and to provide a framework with which you may build your own unique protocol.

The example protocols provide information on what could be used for these pulse sequences and are not to be considered recommendations by GE Medical Systems. For specific protocols, refer to the protocols on your system.

In addition to listing the information you need to select on the system, the “What You Select” column of the matrix uses two other conventions.

- N/A indicates that the imaging parameter is not applicable to the pulse sequence example.
- N/S indicates that the imaging parameter is not selectable in the pulse sequence example. The system automatically selects these imaging parameters.



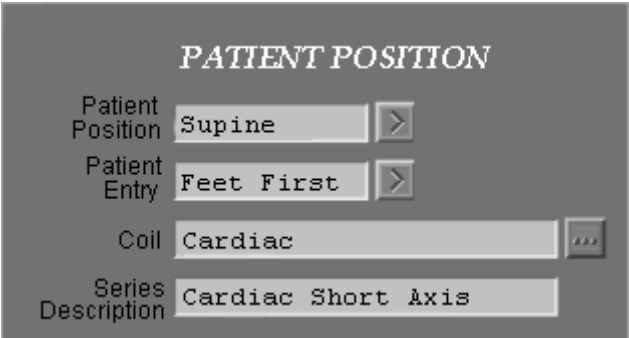
CAUTION: Provide all patients with ear protection prior to any scan to help avoid possible hearing impairment. Acoustic noise levels can exceed 99 dbA in the magnet bore.

Prescribe the Wall Motion Sequence

The Wall Motion Sequence is the first series of the three sequence Myocardial Assessment protocol. It demonstrates functional and anatomical information of the heart. Tagging can be used with this sequence to better visualize contractile function.

The decision matrix (Table 8-2) is only for prescribing a Wall Motion Sequence. The following example protocol is for prescribing a short axis cardiac scan for a TwinSpeed™ or an EchoSpeed™ system.

Table 8-2 Wall Motion Sequence Protocol Example

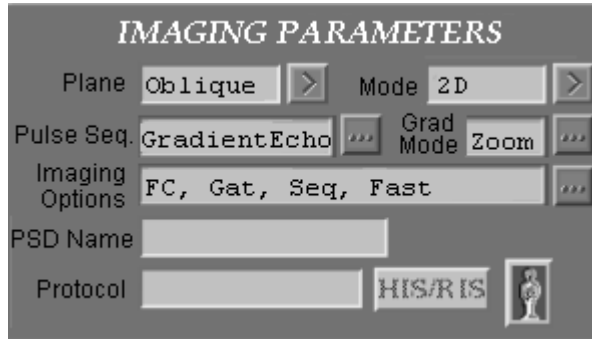
Wall Motion Sequence Protocol Example		
What You Select	Selection Notes	
Scan Rx Desktop		
Scan Rx	Acquire a localizer series	Allows Graphic Rx to become available so you can prescribe slices graphically on the localized image.
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol window becomes active.
Patient Position		
		
Patient Position	Supine	Supine and feet first are recommended to ensure accurate cardiac gating/trigging and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	
Coil	Phased Array > Cardiac	Use a coil that produces the optimum coverage and SNR.
Series Description	Enter a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

Wall Motion Sequence Protocol Example

What You Select

Selection Notes

Imaging Parameters



Plane	Oblique	Oblique is used for proper angle through the heart.
Mode	2D	Allows prescription of a two-dimensional sequence.
Pulse Sequence	Fast Card GRE	Use a FastCard GRE pulse sequence if tagged or a FastCard SPGR if no tags are used.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Imaging Options	FC, Cardiac Gating/ Triggering, and Sequential	Flow Comp increases signal from blood. Cardiac Gating/Triggering and Sequential are automatically selected. Sequential acquires one slice at a time and multiple cardiac phases. It is required for tagging.
PSD Name	N/A	
Protocol	N/A	

Wall Motion Sequence Protocol Example

What You Select

Selection Notes

Scan Timing



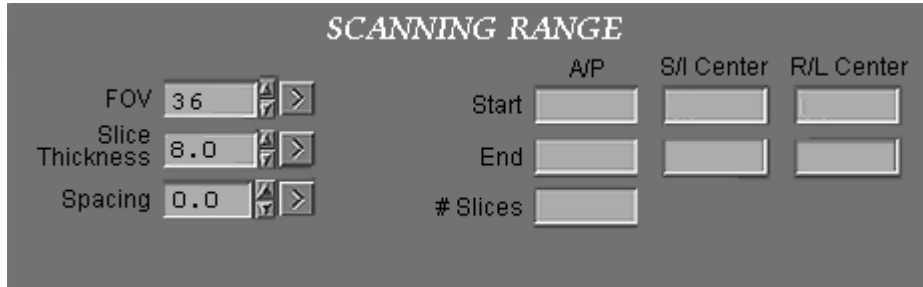
# of echoes	N/S	One echo is automatically selected.
TE	Min Full	Increase TE to produce increased T2* contrast, decreased SNR, and increased magnetic susceptibility artifacts.
TE2	N/A	
TR	N/S	The minimum TR is selected automatically.
Inv. Time	N/A	
T12	N/A	
Flip Angle	20	The typical flip angle value is 20°.
Echo Train Length	N/A	
Bandwidth	31.25	The typical Receive Bandwidth value is 31.25 kHz.
Bandwidth2	N/A	

Wall Motion Sequence Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	Enter 36 in the text box.	Select a FOV that covers the anatomy of interest, about 36 cm for the heart. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	Enter 8 in the text box.	The typical slice thickness value for the heart is 7 to 8 cm. Thin slices produce increased resolution and decreased SNR.
Spacing	Enter 0 in the text box.	Zero spacing is allowed. Slices are acquired sequentially and cross-talk is not a problem.
Start, End Locations		The start and end locations are programmed from the Graphic Rx program after the slices are prescribed.
# Slices		Sequential scans one slice per acquisition. The number of slices indicates the number of acquisitions prescribed.

Acquisition Timing



Freq	256	Increasing the frequency matrix produces increased resolution and decreased SNR.
Phase	Enter 128 in the text box.	Phase controls scan time and may control resolution.

Wall Motion Sequence Protocol Example		
What You Select		Selection Notes
NEX	1	One NEX for sufficient SNR and a reasonable scan time.
Phase FOV	0.75	Select a phase FOV to prevent wrapping of anatomy. Choices are 1.0, 0.75, and 0.5. Reducing the phase matrix decreases scan time, FOV in the phase direction, and SNR (slightly).
Freq DIR	Unswapped	The direction displayed is the default frequency direction which is typically the long axis of the image. Leave the frequency direction unswapped.
Auto Center Freq	Water	The CF peak that will be set during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Autoshim can improve image quality and is recommended for this sequence.
Phase Correct	Off	Provides no additional benefits for this sequence and increases prescan time.
# of Locs Before Pause	1	After you prescribe the slices, return to this screen and prescribe an automatic pause in the scan at predetermined points for breath-hold studies.

Additional Parameters - SAT



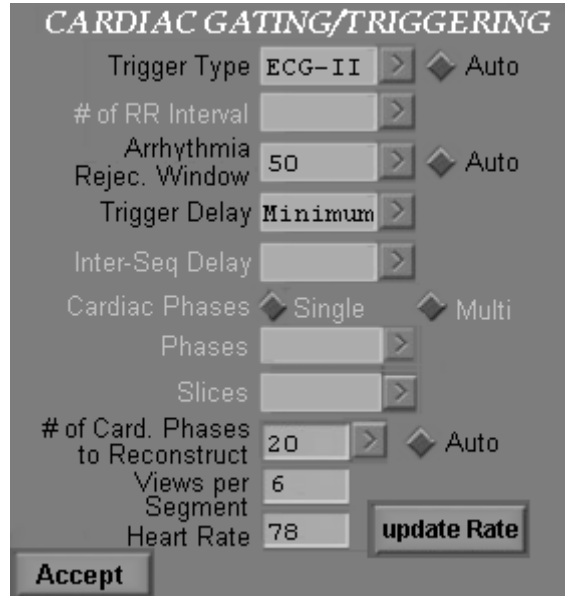
Tag Type	[Stripe] or [Grid]	Sets spatial SAT pulses over anatomy of interest to obtain cardiac images sensitive to tissue motion.
Tag Pixel Spacing	Specify a Pixel separation.	Sets the distance between the tag bands. It is defaulted to a value of 7 pixels and the minimum allowed is 2 pixels. The frequency matrix divided by two ($XRES \div 2$) determines the maximum setting.
Accept	[Accept]	Confirms SAT prescription and closes the SAT Rx Additional Parameter screen.

Wall Motion Sequence Protocol Example

What You Select

Selection Notes

Additional Parameters - Gating/Triggering



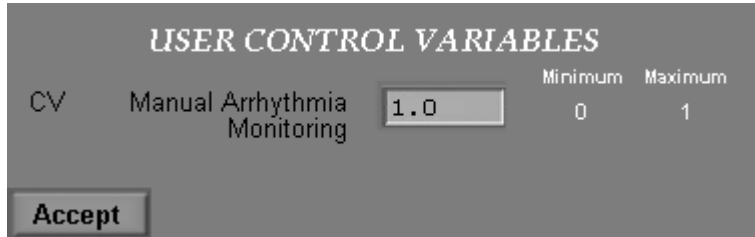
Trigger Type	Select the best lead.	When ECG gating, select the lead that provides the best signal.
# of R-R Interval	N/A	
Arrhythmia Rejection Window	50	Values around 50% are most commonly used to allow a reasonable latitude.
Trigger Delay	Minimum	The most minimum TD is desired to cover the full R-R Interval.
Inter-Seq Delay	N/A	
Cardiac Phases	N/A	
# of Card. Phases to Reconstruct	20	Sets the number of cardiac phases to be reconstructed.
Views per Segment	6	The typical value is 1 to 8 VPS. See the VPS Guide for your patient's heart rate.
Heart Rate	[update Rate]	Lets the system obtain an automatic reading of the current heart rate. Updates the rate prior to beginning the scan.
Accept	[Accept]	Confirms the selected values and closes Gating/Triggering Additional Parameter screen.

Wall Motion Sequence Protocol Example

What You Select

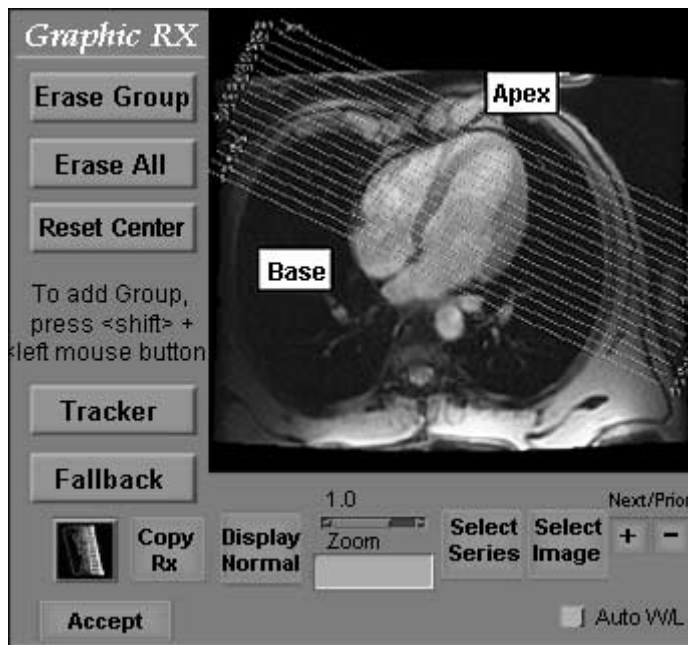
Selection Notes

Additional Parameters - User CVs



Manual Arrhythmia Monitoring	1.0	Manually monitors arrhythmias. When Auto Arrhythmia Monitoring is on (0), too many triggers are detected outside the TW resulting in an aborted scan.
Accept	[Accept]	Confirms selection of User CV and closes the Additional Parameter screen.

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Prescribe the slices from the cardiac base to the apex to display the graphic prescription. Select the adjustment handles to angle, draw, and remove slices. Position the slices to cover anatomy of interest and view the Advisory Panel to note the maximum number of slices per acquisition and the number of acquisitions you are prescribing. The scan time increases as the number of acquisitions increase.

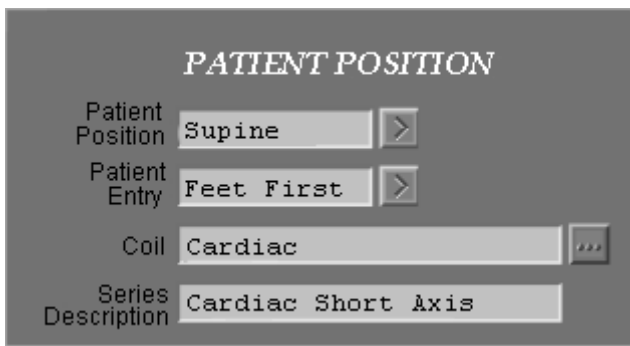
Wall Motion Sequence Protocol Example		
What You Select		Selection Notes
Copy Rx	[Copy Rx] (optional)	If you had previously graphically prescribed an oblique series with the same FOV and slice thickness, the prescription can be copied to the exact locations of the prior series.
Reset Center	[Reset Center] (if necessary)	Re-establishes the FOV center on a different localized slice.
Erase All	[Erase All] (If necessary)	Eliminates the entire graphic prescription from the screen and allows you to start over.
Accept	[Accept]	Confirms the cursor position and closes the Graphic Rx Additional Parameter screen.
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Prep Scan	[Prep Scan]	Performs Auto Prescan and readies the system for data acquisition.
Scan	[Scan]	Initiates the acquisition. Instruct the patient to hold his/her breath as long as possible, until the scan stops, if able.

Prescribe the First Pass Sequence

The First Pass Sequence is the second step in the Myocardial Assessment protocol. This is a cardiac gated FGRET sequence with Multi Phase. Multiple images are acquired at each slice location over a defined number of cardiac cycles. Each slice location is obtained at the same phase of the cardiac cycle. This sequence also uses IR Prep to suppress the myocardium and enhance T1 contrast so that the tissue is better visualized. The First Pass Sequence demonstrates the perfusion abilities of the myocardium.

The decision matrix (Table 8-3) is only for prescribing a First Pass Sequence. The following example protocol is for prescribing a short axis cardiac scan for a TwinSpeed or an EchoSpeed system.

Table 8-3 First Pass Sequence Protocol Example

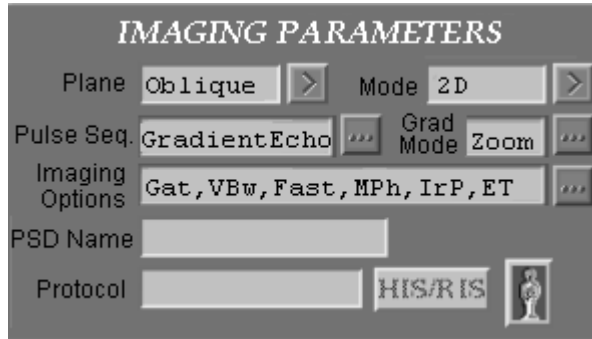
First Pass Sequence Protocol Example		
What You Select		Selection Notes
Scan Rx Desktop		
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol window becomes active.
Patient Position		
		
Patient Position	Supine	Supine and feet first are recommended to ensure accurate cardiac gating/trigging and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the cable to its attachment point on the dog-house.
Patient Entry	Feet First	
Coil	Phased Array > Cardiac	Use a coil that produces the optimum coverage and SNR.
Series Description	Enter a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

First Pass Sequence Protocol Example

What You Select

Selection Notes

Imaging Parameters



Plane	Oblique	Oblique plane is used to obtain the proper angle through the heart.
Mode	2D	Allows prescription of a two-dimensional sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	Fast GRE ET	Use a Fast Gradient Echo sequence with echo train readout.
Imaging Options	Cardiac Gating Triggering, Variable Bandwidth, Multi Phase, and IR Prepared	Cardiac Gating/Triggering should be selected. Multi Phase is used to acquire multiple images at each slice location. IR Prepared is used to improve T1 contrast.
PSD Name	N/A	
Protocol	N/A	

First Pass Sequence Protocol Example

What You Select

Selection Notes

Scan Timing



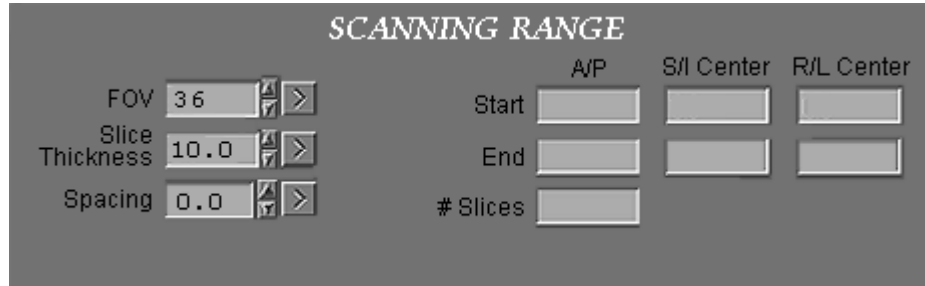
# of echoes	N/S	One echo is automatically selected.
TE	N/S	Only Minimum Full TE is allowed.
TE2	N/A	
TR	N/S	The minimum TR is selected automatically. The minimum TR decreases as RBw increases, and as ETL, frequency matrix, and obliquity decrease.
Inv. Time	N/S	The Inversion Time is automatically calculated based on the other sequence parameters. The TI is generally in the range of 150 to 175 ms when 0.75 PFOV is selected. Otherwise, the TI is >230 ms, causing poor fat suppression.
TI2	N/A	
Flip Angle	Enter 25 in the text box.	The typical flip angle value is 25°.
Echo Train Length	4	As the ETL is increased, TR increases, and image blurring increases. Note the (phase matrix x PFOV) must be an even multiple of the ETL. The system posts a message if this is not followed.
Bandwidth	125	The typical RBw value is 125 kHz. Generally, wider bandwidths are used to minimize TR and TE values.
Bandwidth2	N/A	

First Pass Sequence Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	Enter 36 in the text box.	Select a FOV that covers the anatomy of interest, about 32 to 40 cm. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	10	10 mm is generally used to obtain coverage through the entire heart on the first pass sequence.
Spacing	Enter 0 in the text box.	Zero spacing for complete coverage.
Start, End Locations		The start and end locations are programmed from the Graphic Rx program after the slices are prescribed.
# Slices		The maximum number of slices per acquisition depends on the heart rate, the number of R-R Intervals, the ETL, TR, and frequency matrix.

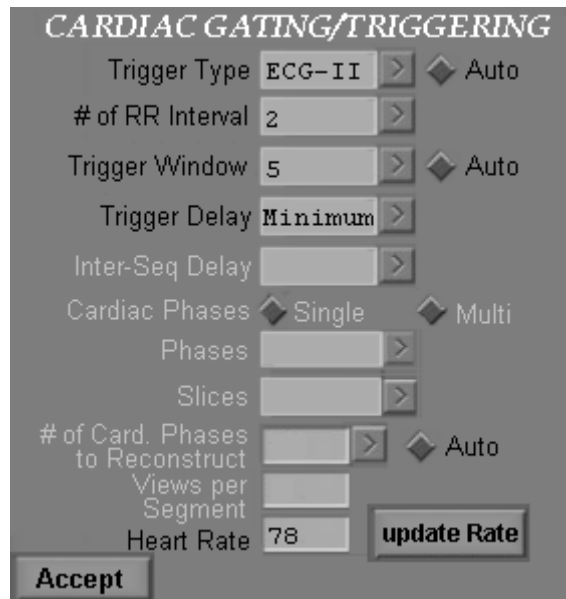
Acquisition Timing



Freq	128	Increasing the frequency matrix decreases echo space, SNR, the number of slice locations allowed, while increasing resolution. Available selections are 64 to 256, in steps of 32.
Phase	128	Phase controls scan time and resolution. The phase matrix cannot exceed the frequency matrix. Available selections are 64 to 256, in steps of 32. Note the (phase matrix x PFOV) must be an even multiple of the ETL.

First Pass Sequence Protocol Example		
What You Select		Selection Notes
NEX	N/S	One NEX is used automatically.
Phase FOV	0.75	Select a PFOV of 1.0 to prevent wrapping of anatomy. Choices are 1.0, 0.75, and 0.5. Reduce the phase matrix to decrease scan time, FOV in the phase direction, and SNR (slightly). The (phase matrix x PFOV) must be an even multiple of the ETL. Due to effects on T1, 0.75 PFOV is recommended.
Freq DIR	Unswapped	The direction displayed is the default frequency direction which is typically the long axis of the image. Leave the frequency direction unswapped.
Auto Center Freq	Water	The CF peak that will be set during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Autoshim can improve image quality and is recommended.
Phase Correct	Off	Provides no additional benefits and increases prescan time.
# of Locs Before Pause	0	This sequence should not be segmented in relation to time and therefore should not have a pause. The scan time is approximately 40 seconds or more and is performed as a breath hold for as long as possible. Locations before pause should be zero for true perfusion effects.

Additional Parameters - Gating/Triggering

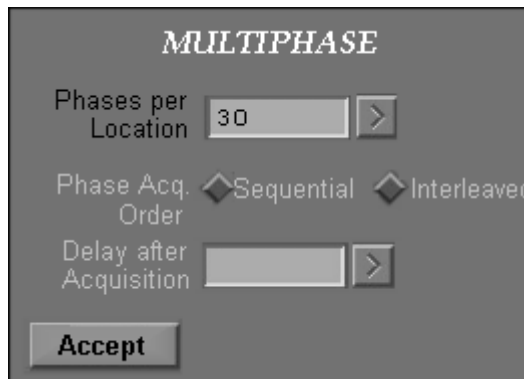


Trigger Type	Select the best lead.	When ECG gating, select the lead that provides the best signal.
# of R-R Interval	2	1, 2, 3, or 4 x R-R Interval is available. As the heart rate increases, a larger R-R Interval is needed for complete coverage of the heart.

First Pass Sequence Protocol Example

What You Select		Selection Notes
Trigger Window	5	Values of 5 to 10 are most commonly used. As the TW increases, the number of slice locations allowed decreases. Use larger values on patients with irregular heart rates. Actual scan times are longer than expected if triggers are detected outside the TW.
Trigger Delay	Minimum	
Inter-Seq Delay	N/A	
Cardiac Phases	N/A	
# of Card. Phases to Reconstruct	N/A	
Views per Segment	N/A	
Heart Rate	[update Rate]	
Accept	[Accept]	Confirms the selected values and closes Gating/Triggering Additional Parameter screen.

Additional Parameters - Multi Phase



Phases per Location	Enter 30 in the text box.	Defines the number of times the sequence repeats, and therefore, the number of images acquired for each slice location. Typically 30 to 45 phases.
Phase Acq. Order	N/A	
Delay after Acquisition	N/A	
Accept	[Accept]	Confirms the selected value and closes Multi Phase Additional Parameter screen.

First Pass Sequence Protocol Example

What You Select

Selection Notes

Additional Parameters - User CVs

USER CONTROL VARIABLES

			Minimum	Maximum
CV3	Echo tuning mode: (1=on, 0=off)	0.00	0	1
CV5	Echo delay (us):	0.00	-50	50
CV6	Manual echo alignment: (1=on, 0=off)	0.00	0	1
CV7	Ramp Sampling: (1=on, 0=off)	0.00	0	1
CV10	turbo_acq: (1=on, 0=off)	0.00	0	1

Accept

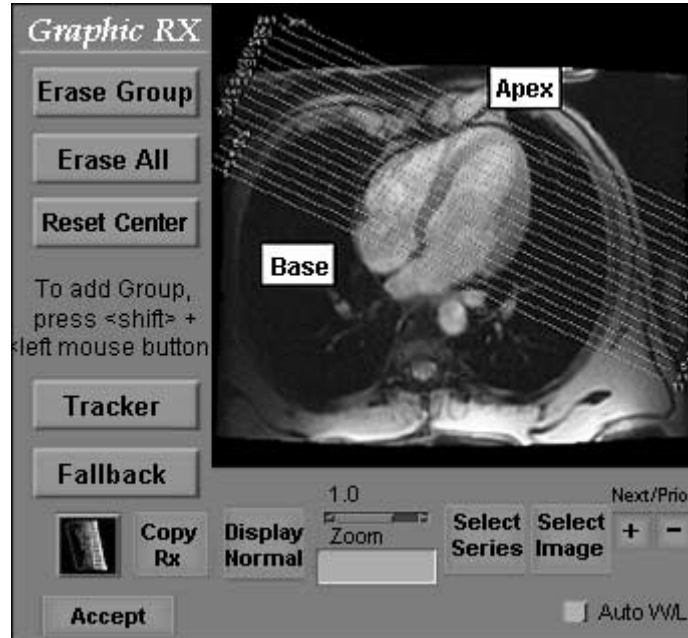
Echo tuning mode	0.00	All User CVs for this sequence are turned off (0=off). Refer to the What Do I Need to Know About... section for the discussion on Manual Echo Alignment.
Echo delay	0.00	
Manual echo alignment	0.00	
Ramp Sampling	0.00	
turbo_acq	0.00	
Accept	[Accept]	Confirms the selected values and closes User CVs Additional Parameter screen.

First Pass Sequence Protocol Example

What You Select

Selection Notes

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Prescribe the slices from the cardiac apex to the base to display the graphic prescription. Select the adjustment handles to angle, draw, and remove slices. Position the slices to cover anatomy of interest and view the Advisory Panel to note the maximum number of slices per acquisition and the number of acquisitions you are prescribing.
Copy Rx	[Copy Rx] (optional)	If you had previously graphically prescribed an oblique series with the same FOV and slice thickness, the prescription can be copied to the exact locations of the prior series.
Reset Center	[Reset Center] (if necessary)	Re-establishes the FOV center on a different localized slice.
Erase All	[Erase All] (If necessary)	Eliminates the graphic prescription from the screen and allows you to start over.
Accept	[Accept]	Confirms the cursor position and closes the Graphic Rx Additional Parameter screen.
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.

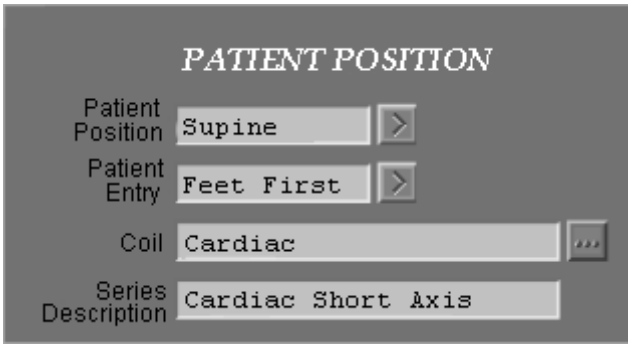
First Pass Sequence Protocol Example		
What You Select		Selection Notes
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Prep Scan	[Prep Scan]	Performs Auto Prescan and readies the system for data acquisition.
Scan	[Scan]	Initiates the acquisition. Instruct the patient to hold his/her breath as long as possible, until the scan stops, if able.

Prescribe the Delayed Enhancement Sequence

The Delayed Enhancement Sequence is the last of three pulse sequences in the Myocardial Assessment protocol to evaluate the LV myocardium. It is used to aid in determining what tissue is viable (alive) or non-viable (dead or infarcted). Recommendations for scan planes and delay times are 5 minute short axis, 10 minute short axis, and 15 minute long axis.

The decision matrix (Table 8-4) is only for prescribing a Delayed Enhancement Sequence. The following example protocol is for prescribing a short axis cardiac scan for a TwinSpeed or an EchoSpeed system.

Table 8-4 Delayed Enhancement Sequence Protocol Example

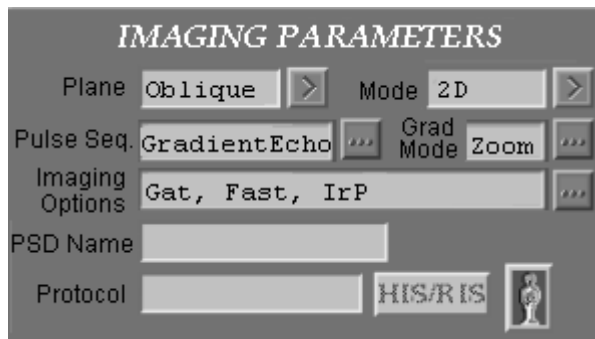
Delayed Enhancement Sequence Protocol Example		
What You Select		Selection Notes
Scan Rx Desktop		
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol window becomes active.
Patient Position		
		
Patient Position	Supine	Supine and feet first are recommended to ensure accurate cardiac gating/triggering and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	
Coil	Phased Array > Cardiac	Use a coil that produces the optimum coverage and SNR.
Series Description	Enter a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

Delayed Enhancement Sequence Protocol Example

What You Select

Selection Notes

Imaging Parameters



Plane	Oblique	Oblique is used for proper angle through the heart.
Mode	2D	Allows prescription of a two-dimensional sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	Fast GRE	Use a Fast GRE pulse sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Imaging Options	Cardiac Gating Triggering and IR Prepared	Cardiac Gating/Triggering should be selected. IR Prepared is used to improve T1 contrast.
PSD Name	N/A	
Protocol	N/A	

Delayed Enhancement Sequence Protocol Example

What You Select**Selection Notes****Scan Timing**

SCAN TIMING

of Echoes 1 2 4

TE

TE2

TR

Prep Time

TI2

Flip Angle

Echo Train Length

Bandwidth

Bandwidth2

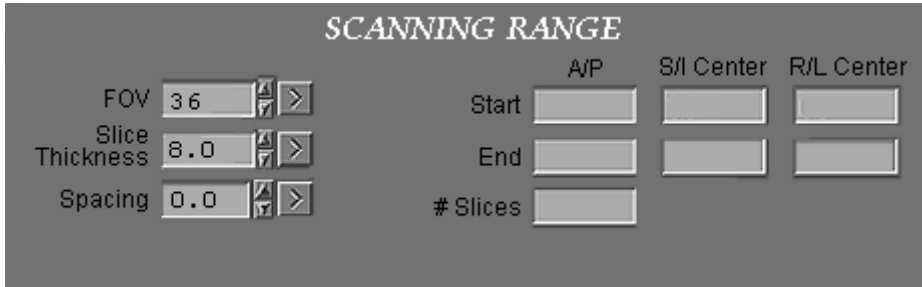
# of echoes	N/S	One echo is automatically selected.
TE	Min Full	Increase TE to produce increased T2* contrast, decreased SNR, and increased magnetic susceptibility artifacts.
TR	N/S	The minimum TR is selected automatically.
Prep Time	200	The typical TI value with IR Prepared and 1 R-R selected is 200. The typical TI value with 2 R-R is 325. This can change from patient to patient.
TI2	N/A	
Flip Angle	20	The typical flip angle value is 20°.
Echo Train Length	N/A	
Bandwidth	31.25	The typical RBw value is 31.25 kHz.
Bandwidth2	N/A	

Delayed Enhancement Sequence Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	Enter 36 in the text box.	Select a FOV that covers the anatomy of interest, about 36 cm for the heart. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	Enter 8.0 in the text box.	The typical slice thickness value for the heart is 7 to 8 cm. Thin slices produce increased resolution and decreased SNR.
Spacing	Enter 0.0 in the text box.	Zero spacing for complete coverage.
Start, End Locations		The start and end locations are programmed from the Graphic Rx program after the slices are prescribed.
# Slices		Use the minimum number of locations needed to cover the entire heart. The R-R Interval and TW affect the number of slices per acquisition. As the heart rate increases, the slices per acquisition decreases. Increase the TW and the slices per acquisition decreases. The number of acquisitions is shown on the Advisory panel.

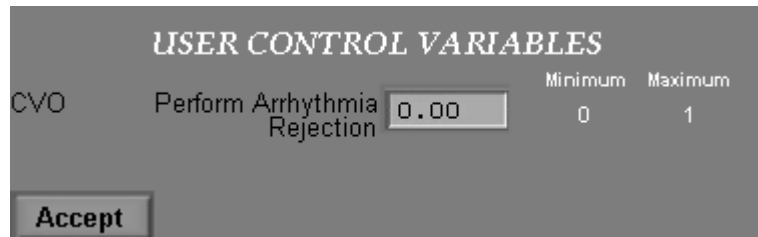
Acquisition Timing



Freq	256	Increasing the frequency matrix produces increased resolution and decreased SNR.
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Delayed Enhancement Sequence Protocol Example		
What You Select		Selection Notes
Phase	192	Phase controls scan time and may control resolution.
NEX	2	Two NEX for sufficient SNR and a reasonable scan time.
Phase FOV	0.75	Choices are 1.0, 0.75, and 0.5. Reduce the phase matrix and thus decrease scan time, FOV in the phase direction, and SNR (slightly).
Freq DIR	Unswapped	The direction displayed is the default frequency direction which is typically the long axis of the image. Leave the frequency direction unswapped.
Auto Center Freq	Water	The CF peak that will be set during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Autoshim can improve image quality and is recommended.
Phase Correct	Off	Provides no additional benefit for this sequence and increases prescan time.
# of Locs Before Pause	1	Prescribes an automatic pause in the scan at predetermined points for breath-hold studies. You can only acquire one slice per breath hold for this sequence.

Additional Parameters - User CVs



Perform Arrhythmia Rejection	0.00	Using Arrhythmia Rejection (1) results in an increase in scan time if triggers occur prior to the TW, but image quality will improve. Too many triggers detected outside the TW results in an aborted scan.
Accept	[Accept]	Confirms selection of User CV and closes the Additional Parameter screen.

Delayed Enhancement Sequence Protocol Example

What You Select

Selection Notes

Additional Parameters - Gating/Triggering

CARDIAC GATING/TRIGGERING

Trigger Type Auto

of RR Interval

Trigger Window Auto

Trigger Delay

Inter-Seq Delay

Cardiac Phases Single Multi

Phases

Slices

of Card. Phases to Reconstruct Auto

Views per Segment

Heart Rate

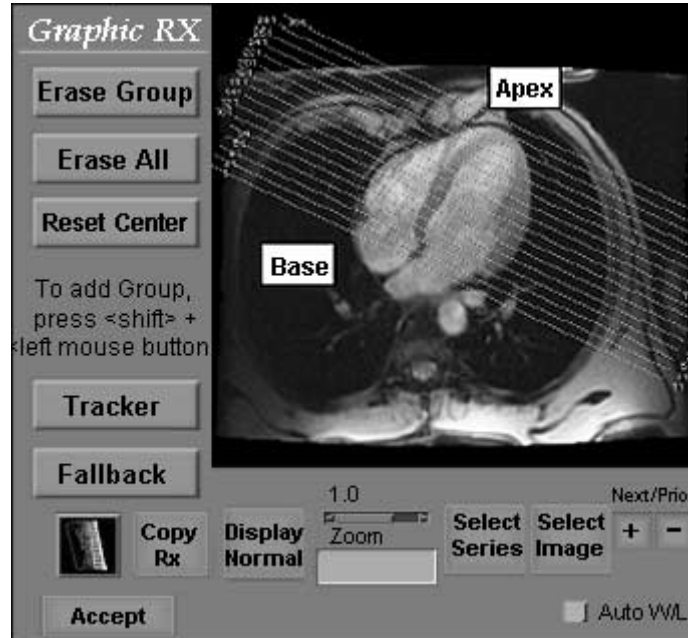
Trigger Type	Select the best lead.	When ECG gating, select the lead that provides the best signal.
# of R-R Interval	1	1 or 2 x R-R Intervals are available to change your image contrast.
Trigger Window	20	The typical value for TW for this sequence is 20.
Trigger Delay	Enter value of 60% of the R-R Interval value.	Note the patient's R-R Interval, calculate 60% of the value, and input the new value for the TD. For example, if your patient's R-R Interval is 780, then 60% x 780 = 468. You would then type in 468 in the TD text box.
Inter-Seq. Delay	N/A	
Cardiac Phases	N/A	
# of Card. Phases to Reconstruct	N/A	
Views per Segment	24	To collect the images faster, since the sequence acquires one slice per breath hold, typical values are 24 to 32 VPS.
Heart Rate	[update Rate]	Lets the system obtain an automatic reading of the current heart rate. Update the rate prior to beginning the scan.
Accept	[Accept]	Confirms the selected values and closes the Gating/Triggering Additional Parameter screen.

Delayed Enhancement Sequence Protocol Example

What You Select

Selection Notes

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Prescribe the slices from cardiac apex to base to display the graphic prescription. Select the adjustment handles to angle, draw, and remove slices. Position the slices to cover the anatomy of interest and view the Advisory Panel to note the maximum number of slices per acquisition and the number of acquisitions you are prescribing. The scan time increases as the number of acquisitions increase.
Copy Rx	[Copy Rx] (optional)	If you had previously graphically prescribed an oblique series with the same FOV and slice thickness, the prescription can be copied to the exact locations of the prior series.
Reset Center	[Reset Center] (if necessary)	Re-establishes the FOV center on a different localized slice.
Erase All	[Erase All] (If necessary)	Eliminates the graphic prescription from the screen and allows you to start over.
Accept	[Accept]	Confirms the cursor position and closes Graphic Rx Additional Parameter screen.

Series Control

Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
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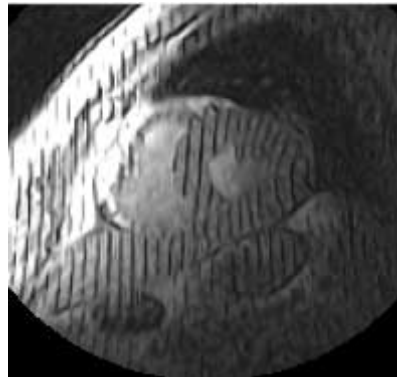
Delayed Enhancement Sequence Protocol Example		
What You Select		Selection Notes
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Prep Scan	[Prep Scan]	Performs Auto Prescan and readies the system for data acquisition.
Scan	[Scan]	Initiates the acquisition. Instruct the patient to hold his/her breath as long as possible, until the scan stops, if able.

Myocardial Assessment Images and Example Protocols

Wall Motion Sequence

The Wall Motion Sequence is the first series in the Myocardial Assessment protocol and can be acquired with a FastCINE SPGR without tags or a FastCINE GRE with tags as shown in Figure 8-4. This sequence allows the assessment of the contractile function of the ventricular wall.

Figure 8-4 Short Axis FastCINE GRE with Tagging



GRE Tagged View

Table 8-5 Wall Motion Sequence Example

Plane	Mode	Pulse Sequence	TE	TR	Flip Angle	RBw	FOV	Slice Thickness	Slice Spacing	Matrix
Oblique	2D	FastCard SPGR (GRE if tagged)	Min Full	N/S	20	31.2	40	8.0	0.0	256x128

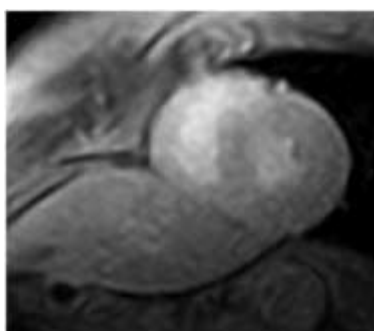
NEX	Phase FOV	Freq Direction	Center Frequency	AutoShim	Phase Correct	Imaging Options	Sat Pulses
1	0.75	Unswap	Water	On	Off	Cardiac Gating/ Triggering, FC, Sequential	Tags optional. Stripe or Grid. Choose pixel separation.

User CVs	Trigger Type	Arr Rej, Window	Trigger Delay	VPS	Phases	Multi Phase Options	Comments
Manual Arrhythmia Monitoring = 1	Select the Best Lead	50	Min	See VPS chart	20	N/A	Cardiac coil recommended

Myocardial Assessment Images and Example Protocols First Pass Sequence

The First Pass Myocardial Perfusion Sequence is the second series in the Myocardial Assessment protocol and is acquired with a cardiac gated FGRET pulse sequence as shown in Figure 8-5. This multi-slice sequence is typically repeated to acquire multiple phases of the cardiac cycle and demonstrates myocardial perfusion.

Figure 8-5 Short Axis FGRET



FGRE - Echo Train

Table 8-6 First Pass Sequence Example

Plane	Mode	Pulse Sequence	TE/TI	TR	Flip Angle	ETL	RBw	FOV	Slice Thickness	Slice Spacing
Oblique	2D	FGRE-ET	Min/Auto	N/S	25	4	125	~32 to 40	10.0	0.0
Matrix	NEX	Phase FOV	Frequency Direction	Center Frequency	Auto Shim	Imaging Options		User CVs		
128x128	1	0.75	Unswapped	Water	On	Cardiac Gating/ Triggering, VBw, MPh, IR Prep		Echo Tuning Mode:0 Echo Delay:0 Man Echo Align:0		
Trigger Type	Trigger Window	Trigger Delay	R-Rs	Phases	Cine Options	MultiPhase Options	Comments			
Select the Best Lead	5 to 10	Min	1 to 4	20	N/A	30 to 45	Cardiac coil recommended			

Myocardial Assessment Images and Example Protocols

Delayed Enhancement Sequence

The Delayed Enhancement Sequence is the last series in the Myocardial Assessment protocol and is acquired with a Fast GRE, IR Prep pulse sequence as shown in Figure 8-6. This sequence assists in determining what tissue is capable of living or capable of working, functioning, or developing.

Figure 8-6 Short Axis Fast GRE



Fast GRE-DE

NOTE: Recommendations for scan planes and delay times are 5 minute short axis, 10 minute short axis, and 15 minute long axis.

Table 8-7 Delayed Enhancement Sequence Example

Plane	Mode	Pulse Sequence	TE/TI	TR	ETL #Shots	Flip Angle	RBw	FOV	Slice Thickness	Slice Spacing
Oblique	2D	Fast GRE	Min Full/ 200	N/S	N/A	20	31.25	~36	8.0	0.0
Matrix	NEX	Phase FOV	Frequency Direction	Center Frequency	Auto Shim	Phase Correct	Imaging Options		Vascular Options	
256x192	2	0.75	Unswapped	Water	On	Off	Cardiac Gating/ Triggering, IR Prep		N/A	
User CVs		Trigger Type	Trigger Window	Trigger Delay	R-Rs	VPS	Multi Phase Options	Comments		
Perform Arrhythmia Rejection = 0		Select the Best Lead	20	60% of R-R Interval	1	24	N/A	Cardiac coil recommended		

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Chapter 9

FGRET Pulse Sequences

Introduction

Fast Gradient Echo-Echo Train (FGRET) is a Fast Gradient Echo (FGRE) sequence with an echo-planar (EPI) readout. FGRET uses a short repetition time (TR) gradient echo pulse sequence with the ability to acquire multiple views per TR using an EPI echo train (ET). Features of both the FGRE and EPI pulse sequences are combined for use in cardiac applications.

This chapter explains the pulsing components and timing factors directly related to the FGRET imaging pulse sequence. It contains the step-by-step instructions to help you learn how to:

- Prescribe the FGRET-MP Sequence
- Perform Manual Echo Alignment for the FGRET-MP Sequence
- Adjust Echo Alignment for the FGRET-MP Sequence
- Prescribe the FGRET-RT Sequence
- Perform Manual Echo Alignment for the FGRET-RT Sequence
- Adjust Echo Alignment for the FGRET-RT Sequence

In addition, this chapter answers the following questions:

1. What is FGRET?
2. When would I use the FGRET pulse sequence?
3. What methods can I use to acquire the FGRET pulse sequence?
4. What are the imaging characteristics of the FGRET pulse sequence?
5. Which imaging options can be used with the FGRET pulse sequence?
6. What are some applications for FGRET sequences?

What Do I Need to Know About...

This section presents the concepts necessary to understand imaging with FGRET pulse sequences. Specifically, you need to understand the following concepts:

- FGRET Basics
- Optimizing the User Control Variables
 - Echo Tuning And Alignment
 - Ramp Sampling
 - Turbo Acquisition Mode
- FGRET with Multi Phase
 - Parameter Selection Effects
 - Image Characteristics
 - Associated Imaging Options
 - Applications
- FGRET for Real Time
 - Parameter Selection Effects
 - Associated Imaging Options
 - Applications

FGRET Basics

FGRET uses a short TR, FGRE pulse sequence with the ability to acquire multiple views (phase encoding steps) per TR using an EPI ET. Features of both the FGRE and EPI pulse sequences are combined for use in cardiac applications. Refer to Table 9-1 for the features of FGRE and EPI that come together to compose the FGRET pulse sequence.

Table 9-1 FGRET Features

Fast Gradient Echo Features	EPI Features
Uniform RF excitation at minimum TRs	Interleaved gradient echo acquisition
Centric phase encoding	Acquisition of multiple views in one TR, the number of TRs being equal to the number of shots
Segmented K-space filling	
FASTCINE, retrospective gating in FastCard-ET	

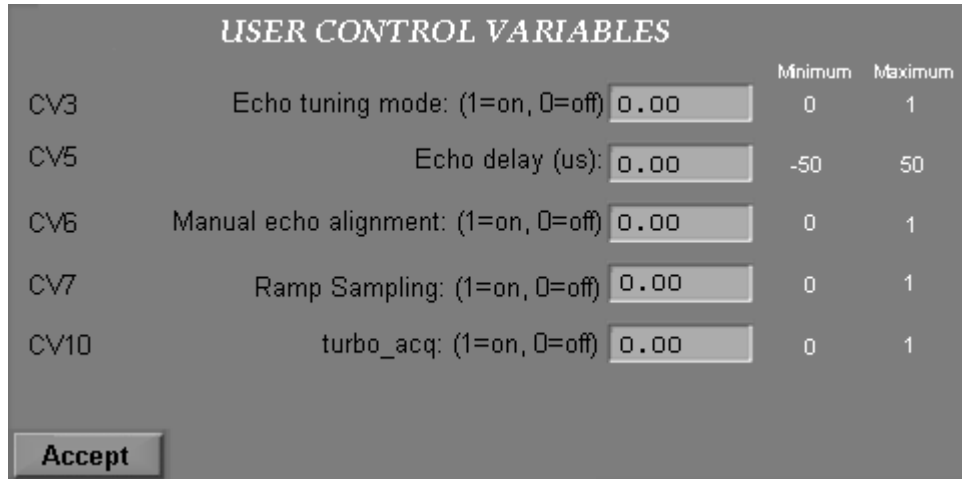
There are two methods for using FGRET.

- FGRET with Multi Phase (FGRET-MP)
 - This is a sequence that supports acquisition of a dynamic myocardial image series.
 - This is a multi-slice sequence used in conjunction with the Multi Phase Imaging Option. The sequence is generally repeated 30 to 60 times for observation of tissue changes over time.
 - Images are annotated “FGR/ET.” MP and EG (for Multi Phase and ECG Gating/Triggering, respectively) are annotated in the Imaging Options line.
- FGRET for Real Time (FGRET-RT)
 - This is a single-slice sequence that is initiated and controlled with the Signa® iDrive™ Pro Plus feature for Real Time Cardiac Acquisitions (RTCAs). When you enable it on your scanner, the data acquisition runs continuously.
 - Images are annotated “FGR/ET.” RT is annotated in the Imaging Options line of the image.

Optimizing User Control Variables

The FGRET-MP and FGRET-RT pulse sequences include several control variables accessed via the User Control Variables (User CVs) screen located in the Additional Parameters area. Selecting the **User CVs Screen** icon, opens the User CVs screen (Figure 9-1).

Figure 9-1 User CVs Screen for FGRET-MP and FRGET-RT



Echo Tuning and Alignment

FGRET-MP is susceptible to ghosting artifacts caused by phase errors that accumulate within the ET. Auto echo alignment is used by the system to compensate for these phase errors. Echo alignment is performed for each slice location at the start of each acquisition.

It is recommended that a trial acquisition be performed before the FGRET series. This acquisition can be used to evaluate the success of the auto echo alignment process. If it appears that there is an unacceptable amount of image blurring as in Figure 9-2, the manual echo alignment procedure can be performed. Alternatively, perform a manual echo alignment series rather than allowing the system to perform the alignment automatically.

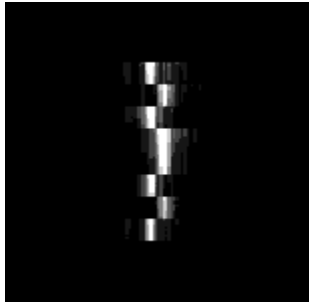
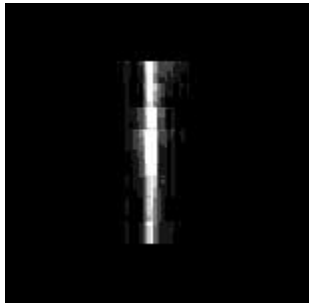
Figure 9-2 Misaligned Echoes

Figure 9-2 exhibits echoes that are misaligned by a few microseconds. By adjusting the echo delay, on the User CVs screen, the echoes can be brought more closely into alignment as shown in Figure 9-3.

Figure 9-3 Aligned Echoes

A trial FGRET-RT acquisition can be performed to evaluate the success of the auto echo alignment process. If it appears that there is an unacceptable amount of image blurring, the manual echo alignment procedure can also be performed.

Manual echo alignment is enabled on the User CVs screen. The CVs Echo tuning mode, Echo delay and Manual Echo Alignment are used to perform manual alignment. The default for these control variables is zero, meaning off. The procedure for manual echo alignment can be found in the **How Do I...** section; refer to Perform Manual Echo Alignment for the FGRET-MP or FRGET-RT Sequence.

NOTE: A properly calibrated MR imaging system is essential to obtain adequate image quality in ET pulse sequences. A service engineer performs system calibration.

Ramp Sampling

Ramp sampling can be used with FGRET sequences. Ramp sampling is performed in the same fashion as an EPI sequence. Ramp sampling expands the usable time during which an echo is acquired (or sampled).

Echo sampling takes place during the rise/fall portion of the readout gradient, as well as during the flat-top portion. The result is decreased echo spacing which, in turn, decreases image blurring. Note that when ramp sampling is enabled on the User CVs screen, the receive bandwidth (RBw) is set to 125 kHz and cannot be changed.

Turbo Acquisition Mode

Turbo acquisition mode allows a portion of the processing, generally completed during acquisition, to be completed during image reconstruction. The result is a decrease in data acquisition time, which provides an improvement in the frame rate. The frame rate is the number of images acquired per second. Turbo acquisition can increase the frame rate by as much as ten percent. The increased frame rate can be important when observing tissue enhancement. The trade-off to using the turbo acquisition mode is a slight increase in image ghosting or blurring. Turning on Ramp Sampling can mitigate these effects.

FGRET with Multi Phase

FGRET with Multi Phase (FGRET-MP) is a cardiac gated, multi-slice acquisition that supports acquisition of a dynamic myocardial image series. Multiple images are acquired at each slice location over a defined number of cardiac cycles. Each image at the same slice location is acquired at the same phase of the cardiac cycle. Therefore, the sequence is not intended to image a slice location at multiple phases of the cardiac cycle.

FGRET-MP acquires all data for one slice in a single cardiac cycle, and multiple slice locations can be acquired within that cardiac cycle if time allows. Selecting Fast GRE ET on the Pulse Sequence window, as well as, Cardiac Gating/Triggering and Multi Phase on the Imaging Options window sets up the sequence. The sequence is typically repeated 30 to 60 times, obtaining a large number of images at each location over a period of time. Each slice location is obtained at the same phase of the cardiac cycle.

After selecting Multi Phase on the Imaging Options window, the Multi Phase screen is used to define the number of times the sequence repeats. This is set as Phases per Location on the Multi Phase screen. If 6 slice locations are prescribed and Phases per Location is set to 30, a total of 180 images will be obtained. Thirty images will be acquired at each location.

The maximum number of slices per acquisition depends on the patient's heart rate, the number of R-R intervals, the ETL, TR, and frequency matrix. Also, a maximum of 64 locations and 512 total images can be prescribed. This means the total number of images in FGRET-MP sequences is based on Equation 9-1.

Equation 9-1 FGRET-MP Total Number of Images

$$\text{(Number of Phases X Number of Locations)} = 512$$

FGRET-MP allows the selection of one, two, three or four R-R intervals on the Cardiac Gating/Triggering screen, resulting in cross R-R imaging.

- When 1 x R-R is used, a complete image of all slice locations is acquired every cardiac cycle.
 - When 1 x R-R is used, the images are acquired in a sequential fashion within one cardiac cycle (e.g., the data for six slices would be obtained in this order; 1, 2, 3, 4, 5, 6).
 - An exception to this is when 1 x R-R is used and Inversion Recovery (IR) Prepared is turned on. In this case, the slices are acquired in an interleaved fashion (e.g., six slices are collected in this order, 1, 3, 5, 2, 4, 6).
- If 2 x R-R is selected, the prescribed slices are acquired across two cardiac cycles.
 - For example, if 6 slice locations are prescribed, images 1, 3, and 5 are acquired across the first cardiac cycle. Images 2, 4, and 6 are then acquired within the second cardiac cycle.
- 2 x R-R (or greater) can be used for obtaining full coverage through the heart when the patient's heart rate is above 80 BPM and all slices cannot be acquired in one cardiac cycle.

The number of slice locations prescribed can be either an odd or even number. Prescribe your slices from the cardiac apex to the base for improved image quality at the cardiac apex. Also, prescribe the maximum number of slice locations allowed per R-R interval to prevent degradation of the first slice images acquired in the sequence.

Parameter Selection Effects

The sequence parameters have different effects that contribute to the FGRET-MP images. The following parameter selections are compatible with FGRET-MP:

- Phased array
- Phase field of view (FOV) less than one (0.5 and 0.75)
- RBw from 32 to 125 kHz
- ETL of 2, 4, 8, or 12
- Number of excitations (NEX) is not selectable, 1 NEX is automatically used. Therefore, adjust other scan parameters to increase SNR.

The following factors can be affected by altering the values for a particular parameter:

- Contrast
- Resolution
- Temporal resolution

Factors that affect Contrast

FGRET-MP can also use a saturation prep-pulse by selecting IR Prepared on the Imaging Options window. IR Prepared can be used to suppress the myocardium and enhance T1 contrast so the tissue is better visualized. An added benefit is the inversion times (TI) used also provide some fat suppression.

The prep-pulse used is a notched pulse; it is applied at a width covering half the number of prescribed slice locations on either side of the current slice. The prep-pulse prepares the next slice prior to acquisition of the current slice. The TI times are longer than the time it takes to acquire a slice. The prep time (TI time) is calculated automatically based on sequence parameters and cannot be edited. The actual TI time is annotated on the images; e.g., TI:173.

The flip angle for this sequence is typically set between 15° to 25°. The optimal flip angle is 25°, causing the myocardium to be darker.

Note that the prep pulse is not applied to the first slice location; therefore, the image contrast for that slice differs from the remaining slices. Also, when FGRET-MP is used in conjunction with IR Prepared, the slices are acquired in an interleaved fashion even when 1 x R-R interval is selected.

Factors that Affect Resolution

The FOV you select should be the size of the patient to obtain optimal image resolution for the anatomy being examined. Anatomy outside the FOV in the phase directions wraps into the image since NPW is not compatible with FGRET. Keep in mind that you can use 0.75 Phase FOV as well.

The slice thickness you choose should be between 8 to 10 mm to cover the heart. An 8 mm slice thickness produces better resolution, but the 10 mm slice thickness may produce a better signal-to-noise ratio (SNR).

Your frequency and phase matrix choices should be 128x128 for optimal resolution, echo spacing, and SNR. The phase matrix also controls scan time and cannot exceed the value of the frequency matrix.

Factors that Affect Temporal Resolution

Temporal resolution is related to the number of phases acquired in the least amount of time. Table 9-2 describes what effect specific parameters have on temporal resolution in the FGRET sequence.

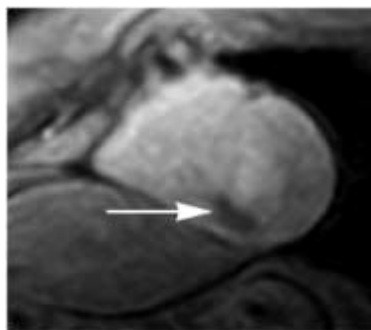
Table 9-2 Effects on Temporal Resolution

Parameter	Temporal Resolution
↑ TR	↓
↑ ETL	↑
↑ Bandwidth	↑
↑ Phase FOV	↓

Image Characteristics

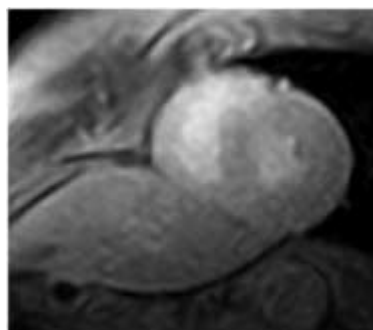
FGRET-MP demonstrates an assessment of myocardial tissue. This sequence allows high temporal resolution, while applying sufficiently long inversion time to allow T1 weighting. FGRET-MP images can also be acquired under cardiac stress and rest conditions as shown in Figure 9-4.

Figure 9-4 Images acquired with the FGRET sequence. Note the filling defect is only noticeable on the image that was acquired under stress conditions.



FGRET

Representing a defect under stress conditions.



FGRET

No defect under rest conditions.

Associated Imaging Options

Imaging Options provide image processing or filters for enhancing anatomical features or reducing noise. In Table 9-3, the Xs indicate the imaging options available for use with the FGRET-MP pulse sequence.

Table 9-3 FGRET-MP Pulse Sequence Imaging Options

Imaging Options			
	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP		Extended Dynamic Range
X	Square Pixel	X*	Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer		Sequential
X	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF	X	IR Prepared
	DE Prepared	X	Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

NOTE: *Surface Coil Intensity Correction (SCIC) is available with the Torso coil. There are no SCIC parameters for the Cardiac coil.

Applications

FGRET-MP imaging can be used in clinical applications to obtain myocardial images with high temporal resolution.



WARNING: The system cardiac gating waveforms are not to be used for physiologic monitoring. The patient's condition may not be reflected, resulting in improper emergency medical treatment.

FGRET for Real Time

FGRET for Real Time (FGRET-RT) is a fast gradient echo-echo train sequence performed using RTCA with Signa *i*Drive Pro Plus to obtain real time image data with interactive scan plane manipulation.

FGRET-RT, sometimes called "fluoro" mode, has been developed to provide real time localization of cardiac anatomy. FGRET-RT is prescribed in the same manner as any *i*Drive RTCA series. Once data acquisition is initiated on the Acquire tab, the data acquisition runs continuously. Your input is required on the Acquire tab to manipulate the scan plane, but Acquire tab Image Contrast tools are not available for FGRET-RT. You can review and save the images in the same fashion as any other *i*Drive image.

NOTE: Refer to Real Time Imaging chapter in this guide for additional information on *i*Drive Pro Plus.

Due to the large ETs used in FGRET-RT, the sequence is susceptible to ghosting artifacts caused by phase errors. The use of fat saturation (SAT) and low flip angles may help decrease the blurring that occurs with FGRET-RT imaging. FGRET-RT also provides auto echo alignment, which is performed to compensate for these phase errors.

Auto echo alignment is performed each time the scan plane is changed during the FGRET real time session. As a result, there are some images acquired as echo alignment is taking place, and these images may exhibit blurring.

Manual echo alignment, a feature also accessed on the User CVs screen, can be used to check and adjust the echo alignment prior to starting the real time data acquisition. Manual echo alignment is not commonly used with FGRET-RT. Refer to this section (**What Do I Need to Know About...**) for details on the User CVs screen, and the Manual Echo Alignment procedure in the **How Do I...** section for details on how to perform manual alignment.

There are several factors you should consider when using FGRET-RT:

- As in any *i*Drive RTCA prescription, only one location is prescribed.
- Spatial SAT pulses are not allowed.

Parameter Selection Effects

The sequence parameters have different effects that contribute to the FGRET-RT images. The following factors can be affected by altering the values for a particular parameter:

- Contrast
- Resolution
- Frame rate

Factors that Affect Contrast

Images acquired with RTCA can display different types of contrast. Image contrast can be controlled by Fat SAT and Flow Compensation (FC). These selections can be prescribed during series prescription. FC and Fat SAT are not available on the Pro Plus Acquire tab to turn on or off. The use of Fat SAT and low flip angles may help compensate for the image blurring that occurs with FGRET-RT. Water SAT is not allowed. The Contrast tools on the Pro Plus Acquire tab: IR, SAT, Fat SAT, SPGR, and FC, are not available for FGRET-RT.

Factors that Affect Resolution

Prescribe a FOV that covers the anatomy of interest. Small FOVs produce increased resolution, decreased SNR, and may increase the minimum TE. Keep in mind that anatomy outside of the phase FOV could result in aliasing. Refer to Table 9-4 for additional parameter selections that affect image resolution with FGRET-RT.

Table 9-4 Effects on Resolution

Parameter	Resolution
↑ Slice Thickness	↓
↑ Frequency Matrix	↑
↑ Phase Matrix	↑
Square Pixels	↑

Factors that Affect Frame Rate

Several series parameters affect the frame rate (FPS) during real time data acquisition. Frame rate can be affected by the parameters shown in Table 9-5. RBw affects the readout time. As bandwidth increases, the system samples faster during the echo which decreases the minimum TR. The frequency matrix also affects the readout time. As the frequency matrix increases, the system must read more samples during the echo which increases the minimum TR.

Table 9-5 Affects on Frame Rate

Parameter	Frame Rate
↑ RBw	↑
Fat Sat	↓
↑ ETL	↑
↑ Frequency Matrix	↓

Associated Imaging Options

Imaging Options provide image processing or filters for enhancing anatomical features or reducing noise. In Table 9-6, the Xs indicate the imaging options available for use with the FGRET-RT pulse sequence.

Table 9-6 FGRET-RT Pulse Sequence Imaging Options

Imaging Options			
	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP		Extended Dynamic Range
X	Square Pixel		Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer		Sequential
	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF		IR Prepared
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station	X*	Real Time
	T2 Prep		Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

NOTE: *Real Time must be selected to acquire FGRET-RT images.

Applications

FGRET-RT can be used to quickly obtain localizer images and locations for imaging cardiac anatomy, as well as other areas of the body.

How Do I...

This section provides the step-by-step instructions for prescribing FGRET imaging pulse sequences and for performing manual echo alignment. Specifically, it describes how to:

- Prescribe the FGRET-MP Sequence
- Perform Manual Echo Alignment for the FGRET-MP Sequence
- Adjust Echo Alignment for the FGRET-MP Sequence
- Prescribe the FGRET-RT Sequence
- Perform Manual Echo Alignment for the FGRET-RT Sequence
- Adjust Echo Alignment for the FGRET-RT Sequence

Decision Matrix

A decision matrix is used in this section to provide examples of what values could be selected for prescribing a particular sequence. The purpose of the decision matrix is to help you understand the trade-offs that occur when you change the values for a particular parameter and to provide a framework with which you may build your own unique protocol.

The example protocols provide information on what could be used for these pulse sequences and are not to be considered recommendations by GE Medical Systems. For specific protocols, refer to the protocols on your system.

In addition to listing the information you need to select on the system, the “What You Select” column of the matrix uses two other conventions.

- N/A indicates that the imaging parameter is not applicable to the pulse sequence example.
- N/S indicates that the imaging parameter is not selectable in the pulse sequence example. The system automatically selects these imaging parameters.



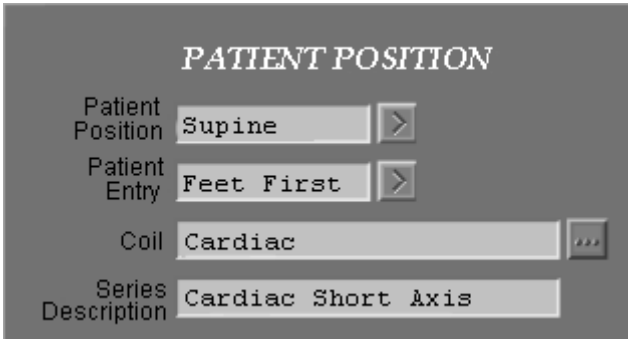
CAUTION: Provide all patients with ear protection prior to any scan to help avoid possible hearing impairment. Acoustic noise levels can exceed 99 dbA in the magnet bore.

Prescribe the FGRET-MP Sequence

The FGRET-MP sequence is useful in clinical applications to obtain myocardial images. It is a cardiac gated sequence with the Multi Phase Imaging Option. Multiple images are acquired at each slice location over a defined number of cardiac cycles. Each slice location is obtained at the same phase of the cardiac cycle. This sequence also uses IR Prepared to suppress the myocardium and enhance T1 contrast so that the tissue is better visualized.

The decision matrix (Table 9-7) is only for prescribing the FGRET-MP sequence. The following example protocol is for prescribing an oblique short axis cardiac scan for a TwinSpeed™ or an EchoSpeed™ system.

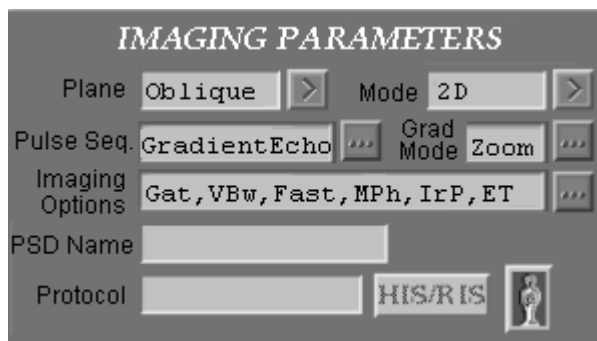
Table 9-7 FGRET-MP Protocol Example (Short Axis Cardiac)

FGRET-MP Protocol Example		
What You Select		Selection Notes
Scan Rx Desktop		
Scan Rx	Acquire a localizer series	Allows Graphic Rx to become available so you can prescribe slices graphically on the localized image.
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol window becomes active.
Patient Position		
		
Patient Position	Supine	Indicates the orientation of the patient. Although compatible with any patient position and entry, supine and feet first are recommended. This Ensures accurate cardiac gating/triggering and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	

FGRET-MP Protocol Example

What You Select		Selection Notes
Coil	Phased Array > Cardiac	Allows selection of the coil from which the signal is transmitted and received. Use a coil that produces the optimum coverage and SNR.
Series	Enter a series description in the text box.	Allows you to enter a brief description of the series being prescribed. If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

Imaging Parameters



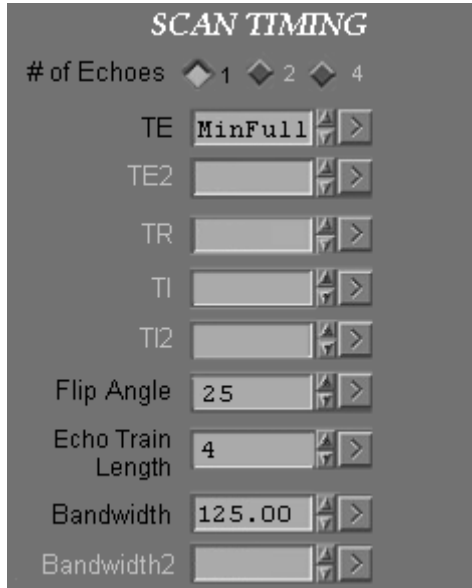
Plane	Oblique	Defines the scan plane of the acquisition. Compatible with any scan plane. Select the plane that best meets your clinical need. For cardiac short or long axis imaging, select oblique for proper angle through the heart.
Mode	2D	Prescribes a two-dimensional sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Seq.	Fast GRE ET	Prescribes the FGRET pulse sequence.
Imaging Options	Cardiac Gating Triggering, Variable Bandwidth, Multi-Phase, and IR Prepared	Provides appropriate options for enhancing anatomical features and reducing noise. Cardiac Gating/Triggering should be selected. Multi Phase acquires multiple images at each slice location. IR Prepared improves T1 contrast.
PSD Name	N/A	
Protocol	N/A	

FGRET-MP Protocol Example

What You Select

Selection Notes

Scan Timing



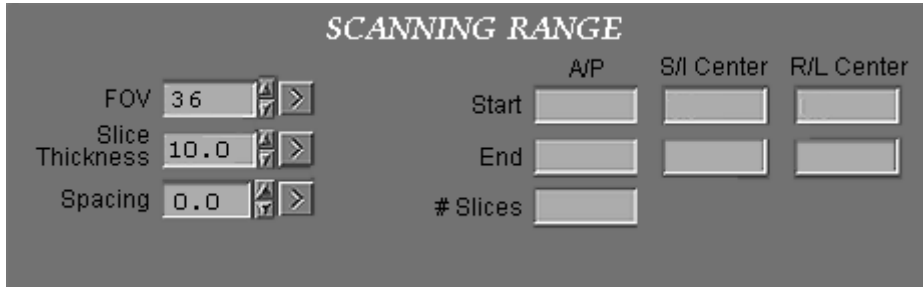
# of echoes	N/S	One echo is selected automatically.
TE	Min Full	The only selection available is minimum full.
TE2	N/A	
TR	N/S	The minimum TR is selected automatically. The minimum TR decreases as RBw increases, and as ETL, frequency matrix, and obliquity decrease.
T1	N/S	The T1 is automatically calculated based on the other sequence parameters. The T1 is generally in the range of 150 to 175 ms when 0.75 PFOV is selected. Otherwise, the T1 is >230 ms, causing poor fat suppression.
T12	N/A	
Flip Angle	Enter 25 in the text box.	The typical flip angle value is 25°.
Echo Train Length	4	As the ETL is increased, TR increases, and image blurring increases. Note the (phase matrix x PFOV) must be an even multiple of the ETL. The system posts a message if this is not followed.
Bandwidth	125	The typical RBw value is 125 kHz. Generally, wider bandwidths are used to minimize TR and TE values.
Bandwidth2	N/A	

FGRET-MP Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	36	Defines the size of the area imaged. Select an FOV that covers the anatomy of interest, about 32 to 40 cm. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	10.0	Defines the thickness of the image slice. 10 mm is generally used to obtain coverage through the entire heart on the first pass sequence.
Spacing	Enter 0.0 in the text box.	Places a zero spacing between the prescribed slice locations. Zero spacing is used for complete coverage.
Start, End Locations		Determines the start and end locations from the Graphic Rx program after the slices are prescribed and posts the locations here.
# Slices		Determines the number of slices as prescribed in Graphic Rx and posts it here. Adjust the number of slice locations as necessary. The maximum number of slices per acquisition depends on the heart rate, the number of R-R intervals, the ETL, TR, and frequency matrix.

FGRET-MP Protocol Example

What You Select

Selection Notes

Acquisition Timing



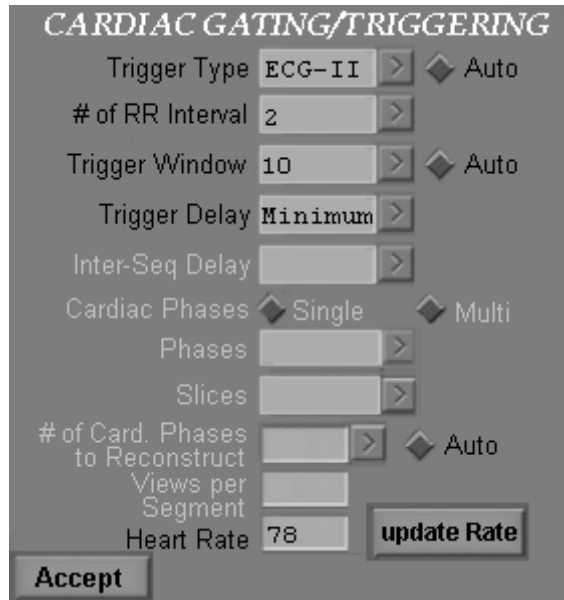
Freq	128	Controls resolution. Increasing the frequency matrix decreases echo space, SNR, the number of slice locations allowed, while increasing resolution. Available selections are 128 to 256, in steps of 32.
Phase	128	Controls scan time and resolution. The phase matrix cannot exceed the frequency matrix. Available selections are 64 to 256, in steps of 32. Note the (phase matrix x PFOV) must be an even multiple of the ETL.
NEX	N/S	One NEX is used automatically.
Phase FOV	0.75	Shortens scan time by scaling down the FOV in the phase direction by either 0.5 or 0.75. A full PFOV of one is also available to prevent wrapping of anatomy. Reduce the phase matrix to decrease scan time, FOV in the phase direction, and SNR (slightly). Note the (phase matrix x PFOV) must be an even multiple of the ETL. Due to effects on TI, 0.75 PFOV is recommended for optimum fat suppression.
Freq DIR	Unswap	Displays the default frequency direction which is typically the long axis of the image. Leave the frequency direction unswapped.
Auto Center Freq	Water	Sets this CF peak during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Improves image quality and is recommended for this sequence.
Phase Correct	N/A	
# of Locs Before Pause	N/A	

FGRET-MP Protocol Example

What You Select

Selection Notes

Additional Parameters - Gating/Triggering

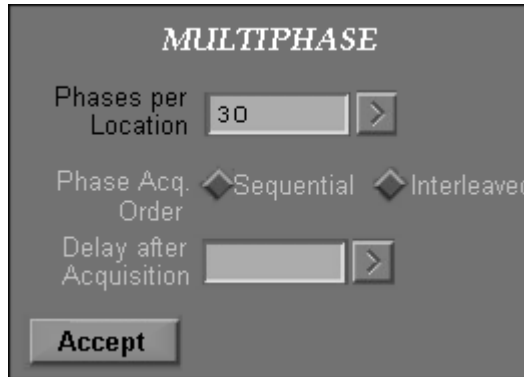


Trigger Type	Select the best lead.	Defines which signal is sent by the cardiac monitor to activate the data acquisition. When ECG gating, select the lead that provides the best signal.
# of R-R Interval	2	Defines the time between the peak of one R-wave and the peak of the next one. Usually 2 R-R intervals allow complete coverage of the heart. 1, 2, 3, or 4 x R-R Interval is available. As the heart rate increases, a larger R-R Interval is needed for complete coverage of the heart.
Trigger Window	10	Defines the period of time where no data is acquired and when the system is waiting for the next R-wave trigger. Values of 10 to 15 are most commonly used. As the TW increases, the number of slice locations allowed decreases. Use larger values on patients with irregular heart rates. Actual scan times are longer than expected if triggers are detected outside the TW.
Trigger Delay	Minimum	Defines the delay time between the occurrence of the triggering pulse and the actual onset of imaging. The most minimum TD is desired to cover the full R-R interval.
Inter-Seq Delay	N/A	
Cardiac Phases	N/A	
# of Card. Phases to Reconstruct	N/A	
Views per Segment	N/A	

FGRET-MP Protocol Example

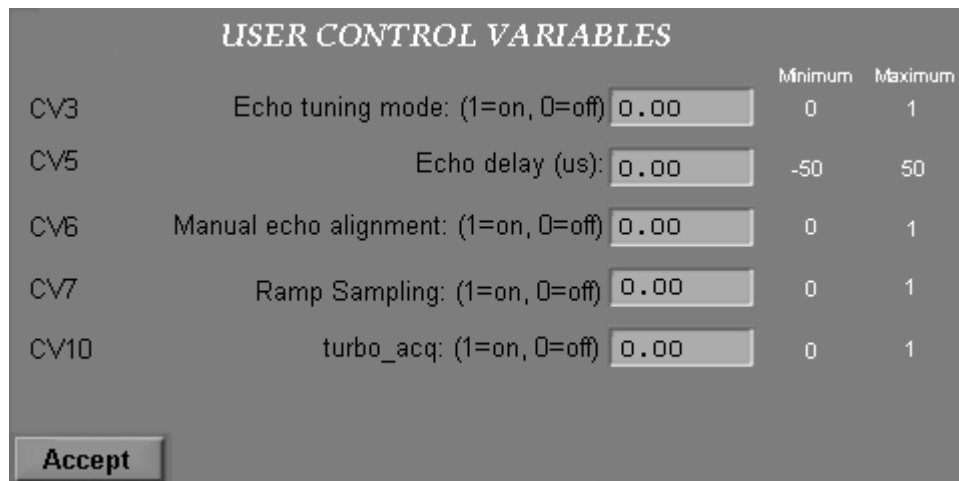
What You Select		Selection Notes
Heart Rate	[update Rate]	Lets the system obtain an automatic reading of the current heart rate. Updates the rate prior to beginning the scan.
Accept	[Accept]	Confirms the selected values and closes Gating/Triggering Additional Parameter screen.

Additional Parameters - Multi Phase



Phases per Location	Enter 30 in the text box.	Defines the number of times the sequence repeats, and therefore, the number of images acquired for each slice location. Typically select 30 to 60 phases.
Phase Acq. Order	N/A	
Delay after Acquisition	N/A	
Accept	[Accept]	Confirms the selected value and closes Multi Phase Additional Parameter screen.

Additional Parameters - User CVs

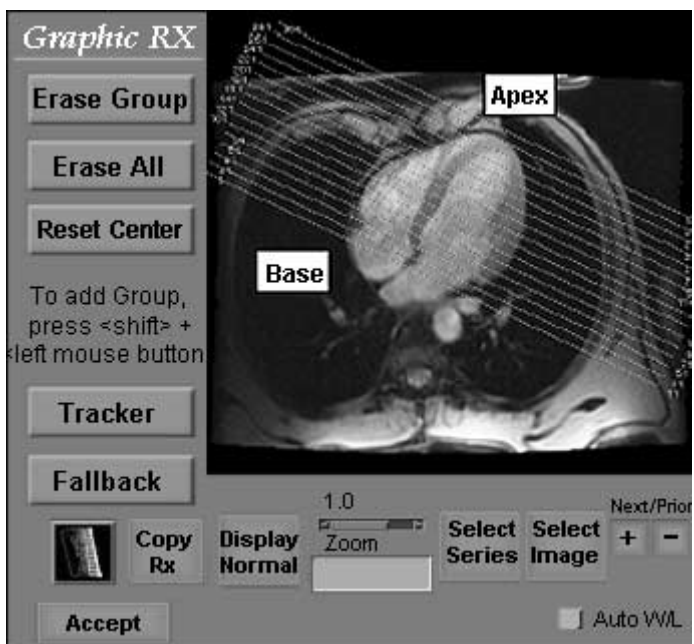


Echo tuning mode	0.00	All User CVs for this sequence are turned off (0=off). Refer to the What Do I Need to Know About... section for the discussion on Manual Echo Alignment.
Echo delay	0.00	

FGRET-MP Protocol Example

What You Select	Selection Notes
Manual echo alignment 0.00	Confirms the selected values and closes the User CVs Additional Parameter screen.
Ramp Sampling 0.00	
turbo_acq 0.00	
Accept [Accept]	

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Allows you to prescribe slices from the cardiac apex to the base for graphic prescription. Select the adjustment handles to angle, draw, and remove slices. Position the slices to cover anatomy of interest and view the Advisory Panel to note the maximum number of slices per acquisition and the number of acquisitions you are prescribing. The scan time increases as the number of acquisitions increase.
Copy Rx	[Copy Rx] (optional)	Copies the exact locations of the prior series if you had previously graphically prescribed a series with the same plane, FOV, and slice thickness.
Erase All	[Erase All] (if necessary)	Eliminates the graphic prescription from the screen and allows you to start over.
Reset Center	[Reset Center] (if necessary)	Re-establishes the FOV center on a different localized slice.
Accept	[Accept]	Confirms the cursor position and closes Graphic Rx.

FGRET-MP Protocol Example		
What You Select		Selection Notes
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Prep Scan	[Prep Scan]	Performs Auto Prescan and readies the system for data acquisition. Select for breath-hold acquisitions.
Scan	[Scan]	Initiates the acquisition. Instruct the patient to hold his/her breath as long as possible, until the scan stops, if able.

Perform Manual Echo Alignment for the FGRET-MP Sequence

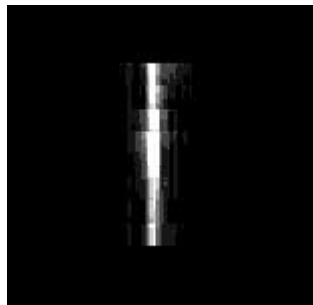
In Brief: Perform Manual Echo Alignment for the FGRET-MP Sequence

1. Prescribe the series to be used for the FGRET-MP acquisition.
2. Turn IR Prepared off.
3. Click the **User CVs Screen** icon.
4. Enter 1 in the **Echo tuning mode** text box.
5. Click **[Accept]**.
6. Click the **Multi Phase Screen** icon.
7. Enter 1 in the **Phases per location** text box.
8. Click **[Accept]**.
9. Click the **Graphic Rx** icon.
10. Prescribe one slice location through the center of the anatomy.
11. Click **[Accept]**.
12. Click **[Save Series]**.
13. Click **[Prepare to Scan]**.
14. Click **[Scan]**.
15. Evaluate the images.
16. Prescribe the FGRET-MP pulse sequence.

Manual Echo Alignment can be performed after performing a trial series if image quality is in question, or this procedure can be performed instead of a trial series. This process allows a manual check of the echo alignment to ensure optimum image quality. Even when this procedure is performed, image quality can be affected by phase offsets which are inherent to ET sequences. This procedure guides you through the process of manually aligning the echoes for the FGRET-MP sequence.

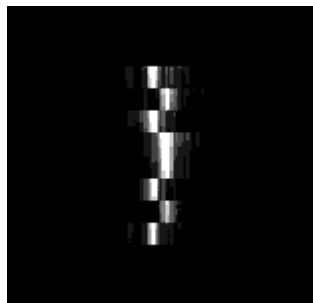
1. Prescribe the series to be used for the FGRET-MP acquisition.
 - ◆ Refer to the FGRET-MP decision matrix.
2. Turn IR Prepared off.
 - ◆ Located on the Imaging Options window.
3. Click the **User CVs Screen** icon.
 - ◆ Located in the Additional Parameters area.
4. Enter 1 in the **Echo tuning mode** text box.
 - ◆ Prompts the system to display a representation of the echoes from which proper alignment can be assessed.
5. Click **[Accept]**.
 - ◆ Accepts the entry and closes the User CVs screen.
6. Click the **Multi Phase Screen** icon.
 - ◆ Located in the Additional Parameters area.
7. Enter 1 in the **Phases per location** text box.
 - ◆ Prescribes one phase per slice location.
8. Click **[Accept]**.
 - ◆ Accepts the entry and closes the Multi Phase screen.
9. Click the **Graphic Rx** icon.
 - ◆ Located in the Additional Parameters area.
10. Prescribe one slice location through the center of the anatomy.
 - ◆ The slice angle, FOV, RBw, and matrix values must be exactly the same as the FGRET series.

11. Click **[Accept]**.
 - ◆ Accepts the prescription and closes the Graphic Rx screen.
12. Click **[Save Series]**.
 - ◆ Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
13. Click **[Prepare to Scan]**.
 - ◆ Downloads the series.
14. Click **[Scan]**.
 - ◆ Auto Prescan is performed and the system initiates the data acquisition with Echo tuning mode on.
15. Evaluate the images.
 - ◆ If the echoes are aligned, continue with step16.



Aligned Echoes

- ◆ If the echoes are misaligned, adjust the echo alignment using the Adjust the Echo Alignment for the FGRET-MP Sequence procedure.



Misaligned Echoes

16. Prescribe the FGRET-MP pulse sequence.
 - ◆ Refer to the FGRET-MP decision matrix.
 - ◆ Set the Manual echo alignment to zero.

Adjust Echo Alignment for the FGRET-MP Sequence

In Brief: Adjust Echo Alignment for the FGRET-MP Sequence

1. Copy and paste the FGRET-MP series used in the Manual Echo Alignment process.
2. Click **[View Edit]**.
3. Click the **User CVs Screen** icon.
4. Enter 1 in the **Echo tuning mode** text box.
5. Enter 6 in the **Echo delay** text box.
6. Enter 1 in **Manual echo alignment** text box.
7. Click **[Accept]**.
8. Click **[Save Series]**.
9. Click **[Prepare to Scan]**.
10. Click **[Scan]**.
11. Evaluate the images.
12. Repeat the acquisition, changing the echo delay each time, until the echoes are aligned as well as possible.
13. Record the value of the optimal echo delay.
14. Prescribe the FGRET-MP pulse sequence.
15. Enter the echo values on the User CVs screen.
16. Scan the FGRET-MP pulse sequence.

Use this procedure if you have performed a manual echo alignment of the FGRET-MP pulse sequence and the echoes are misaligned. Another series must be acquired to adjust the echo alignment. This procedure guides you through the process of adjusting the echo delay to bring the echoes more closely into alignment.

1. Copy and paste the FGRET-MP series used in the Manual Echo Alignment process.
2. Click **[View Edit]**.
 - ◆ Opens the series and allows for changes.
3. Click the **User CVs Screen** icon.
 - ◆ Located in the Additional Parameters area.
 - ◆ The User CVs return to their default state when a new series is selected.
4. Enter 1 in the **Echo tuning mode** text box.
 - ◆ Prompts the system to display a representation of the echoes from which proper alignment can be assessed.
5. Enter 6 in the **Echo delay** text box.
 - ◆ Values from ± 1 to ± 12 .
 - The delay unit is microseconds.
6. Enter 1 in **Manual echo alignment** text box.
 - ◆ Enables manual alignment.
7. Click **[Accept]**.
 - ◆ Accepts the entries and closes the User CVs screen.
8. Click **[Save Series]**.
 - ◆ Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
9. Click **[Prepare to Scan]**.
 - ◆ Downloads the series.
10. Click **[Scan]**.
 - ◆ Auto Prescan is performed and the system initiates the data acquisition with Echo tuning mode on.

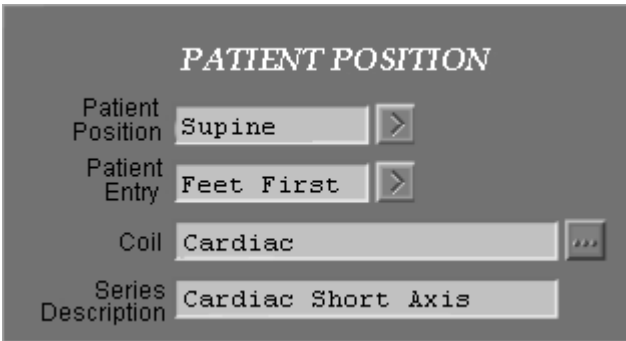
11. Evaluate the images.
 - ♦ If the echoes are aligned, continue with step 13.
 - ♦ If the echoes are misaligned continue with step 12.
 12. Repeat the acquisition, changing the echo delay each time, until the echoes are aligned as well as possible.
 - ♦ Continue to repeat steps 1 to 11 to adjust the echo delay value.
 - ♦ Adjust the echo delay in increments of one.
 - This may be a negative value.
 13. Record the value of the optimal echo delay.
- NOTE:** If you are unable to align the echoes, contact your service engineer.
14. Prescribe the FGRET-MP pulse sequence.
 - ♦ Refer to the FGRET-MP decision matrix.
 - ♦ The slice locations must be the same obliquity as the location used for the manual echo alignment series.
 15. Enter the echo values on the User CVs screen.
 - ♦ Echo tuning mode = 0
 - Zero is off.
 - ♦ Echo delay = the value determined in step 13.
 - ♦ Manual echo alignment = 1
 - One is on.
 16. Scan the FGRET-MP pulse sequence.
 - ♦ Refer to the FGRET-MP decision matrix.

Prescribe the FGRET-RT Sequence

The FGRET-RT sequence is performed using iDrive Pro Plus for RTCAs to obtain real time image data with interactive scan plane manipulation. This is useful to quickly obtain localizer images and locations for imaging cardiac anatomy, as well as other areas of the body.

The decision matrix (Table 9-8) is only for prescribing the FGRET-RT scan. The following example protocol is for prescribing a real time scan for obtaining localizer images for imaging cardiac anatomy on a TwinSpeed or an EchoSpeed system.

Table 9-8 FGRET-RT Protocol Example (Cardiac Localizers)

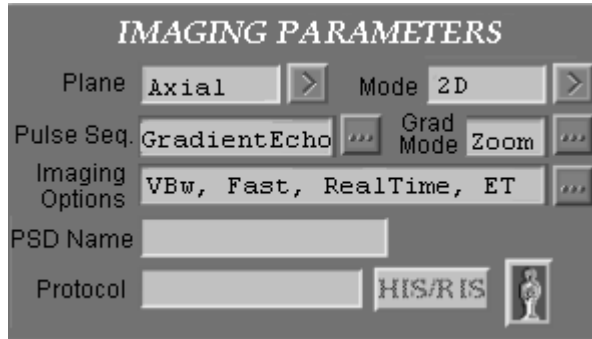
FGRET-RT Protocol Example		
What You Select		Selection Notes
Rx Manager		
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol screen becomes active.
Patient Position		
		
Patient Position	Supine	Indicates the orientation of the patient. Although compatible with any patient position and entry, supine and feet first are recommended. This ensures accurate cardiac gating/triggering and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	
Coil	Phased Array > Cardiac	Allows selection of the coil from which the signal is transmitted and received. Use a coil that produces the optimum coverage and SNR.
Series Description	Enter a series description in the text box.	Allows you to enter a brief description of the series being prescribed. If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

FGRET-RT Protocol Example

What You Select

Selection Notes

Imaging Parameters



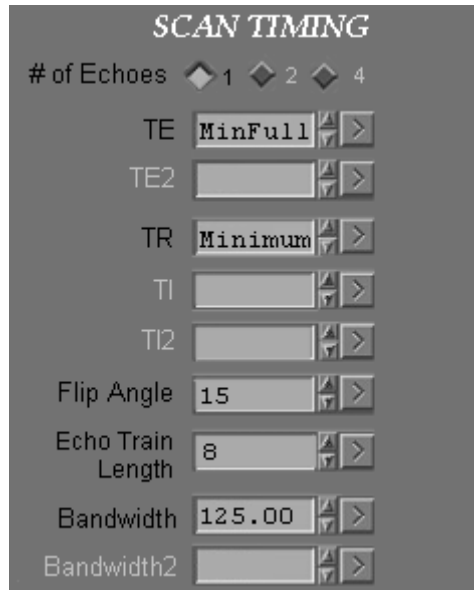
Plane	Axial	Defines the scan plane of the acquisition. Any orthogonal scan plane is allowed to set up the first slice in this real time sequence.
Mode	2D	Prescribes a two-dimensional sequence. 2D is the only mode allowable for real time sequences.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	Fast GRE ET	Prescribes the FGRET pulse sequence.
Imaging Options	Real Time, Variable Bandwidth	Provides appropriate options for enhancing anatomical features and reducing noise. Real Time enables FGRET-RT. VBw is available, but not necessary to alter the RBw. Square Pixels and FC are the only other available options.
PSD Name	N/A	
Protocol	N/A	

FGRET-RT Protocol Example

What You Select

Selection Notes

Scan Timing



# of echoes	N/S	One echo is selected automatically.
TE	Min Full	The only available selection is minimum full.
TE2	N/A	
TR	Minimum	The minimum TR is the only available selection. The minimum TR decreases as RBw increases, and as ETL, frequency matrix, and obliquity decrease.
T1	N/A	
T2	N/A	
Flip Angle	Enter 15 in the text box.	The typical flip angle value is between 12° and 15° to help minimize image blurring.
Echo Train Length	8	As the ETL is increased, image blurring increases, the frame rate increases, and scan time decreases. 2, 4, 8, and 12 ETLs are allowed. You may want to decrease this value if you are operating a HiSpeed™ or SmartSpeed™ system.
Bandwidth	125	As the RBw increases, SNR decreases, minimum TE and TR values result, and image blurring decreases as a result of shorter echo spaces. 32, 62.5, and 125 kHz are allowed.
Bandwidth2	N/A	

FGRET-RT Protocol Example

What You Select

Selection Notes

Scanning Range



FOV	36	Defines the size of the area imaged. Select an FOV that covers the anatomy of interest, about 32 to 40 cm. Anatomy outside the FOV in the phase direction results in aliasing. Small FOVs produce increased resolution, decreased SNR, and can increase the minimum TE value.
Slice Thickness	10.0	Defines the thickness of the image slice. 8 mm to 10 mm is generally used to obtain the home images. This value can be interactively changed during data acquisition.
Spacing	N/A	FGRET-RT is a single slice acquisition; spacing is not required.
Start, End Locations	0.0	Determines the start and end locations. Either Explicit or Graphic Rx can be used to prescribe the single slice location.
# Slices	1	Determines the number of slices as prescribed in Explicit or Graphic Rx and posts it here. Only one slice location is allowed for real time sequences.

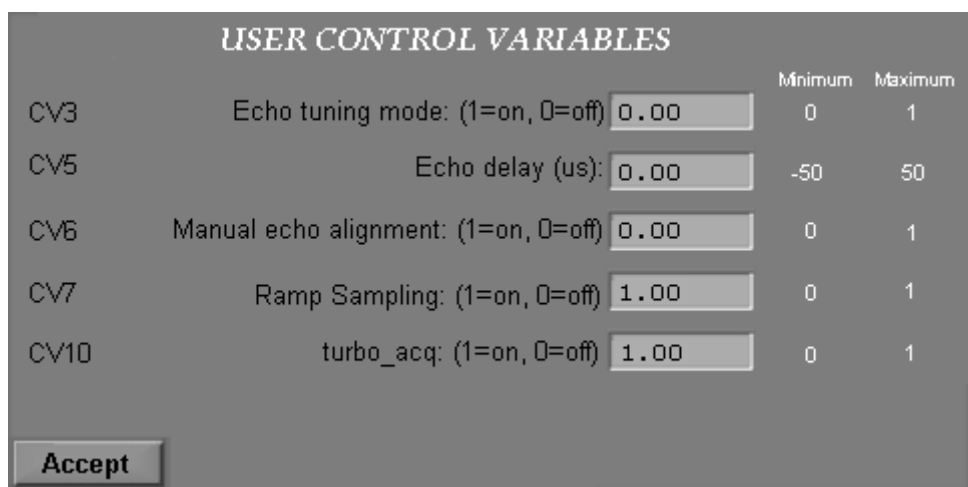
Acquisition Timing



Freq	128	Increasing the frequency matrix decreases echo space, SNR, the number of slice locations allowed, while increasing resolution. Available selections are 64 to 256, in steps of 32.
------	------------	--

FGRET-RT Protocol Example		
What You Select		Selection Notes
Phase	128	The typical value is 96 or 128. The phase matrix cannot exceed the frequency matrix.
NEX	N/S	One NEX is used automatically.
Phase FOV	0.75	Select a phase FOV of one to prevent wrapping of anatomy. Choices are 1.0, 0.75, and 0.5. Reduce the phase matrix to decrease scan time, FOV in the phase direction, and SNR (slightly). The phase FOV dimension is displayed next to the phase FOV factor.
Freq DIR	R/L	Displays the default frequency direction which is typically the long axis of the image. To swap phase and frequency, select the other direction.
Auto Center Freq	Water	Sets this CF peak during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Improves image quality and is recommended for this sequence.
Phase Correct	N/A	
# of Locs Before Pause	N/A	

Additional Parameters - User CVs



Echo tuning mode	0.00	Manual echo alignment is not commonly performed on FGRET-RT. Refer to the What Do I Need to Know About... section for the discussion on manual echo alignment.
Echo delay	0.00	
Manual echo alignment	0.00	
Ramp Sampling	1.00	Decreases the echo space and image blurring. The RBw is fixed at 125 kHz when ramp sampling is enabled. Enter 1 in the text box to use ramp sampling. Leave the text box at the default value of zero if ramp sampling is not desired.

FGRET-RT Protocol Example		
What You Select		Selection Notes
turbo_acq	1.00	Decreases data acquisition times and increases the frame rate. Enter 1 in the text box to use turbo acquisition mode. Recommended with Ramp Sampling to decrease image blurring. This option is not supported with the Body coil.
Accept	[Accept]	Confirms the selected values and closes the User CVs Additional Parameter screen.
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Scan	[Scan]	Initiates Auto Prescan and the iDrive Acquire tab opens. Home images are acquired and at this point, the Acquire tab can be used to navigate through the anatomy and alter image contrast as needed. Scan planes and slice locations can be copied from the iDrive windows to a series in the Rx Manager.

Perform Manual Echo Alignment for the FGRET-RT Sequence

In Brief: Perform Manual Echo Alignment for the FGRET-RT Sequence

1. Prescribe the series to be used for the FGRET-RT acquisition.
2. Turn Real Time off.
3. Click the **User CVs Screen** icon.
4. Enter 1 in the **Echo tuning mode** text box.
5. Click **[Accept]**.
6. Click the **Graphic Rx** icon.
7. Prescribe one slice location through the center of the anatomy.
8. Click **[Accept]**.
9. Click **[Save Series]**.
10. Click **[Prepare to Scan]**.
11. Click **[Scan]**.
12. Evaluate the images.
13. Prescribe the FGRET-RT pulse sequence.

Manual echo alignment can be performed if after performing the FGRET-RT series, image quality is in question. Manual echo alignment can also be performed prior to starting the real time sequence. This process allows a manual check of the echo alignment to ensure optimum image quality. Even when this procedure is performed, image quality can be affected by phase offsets which are inherent to ET sequences. This procedure guides you through the process of manually aligning the echoes for the FGRET-RT pulse sequence.

1. Prescribe the series to be used for the FGRET-RT acquisition.
 - ◆ Refer to the FGRET-RT decision matrix.
2. Turn Real Time off.
 - ◆ Located on the Imaging Options window.
3. Click the **User CVs Screen** icon.
 - ◆ Located in the Additional Parameters area.
4. Enter 1 in the **Echo tuning mode** text box.
 - ◆ Prompts the system to display a representation of the echoes from which proper alignment can be assessed.
5. Click **[Accept]**.
 - ◆ Accepts the entry and closes the User CVs screen.
6. Click the **Graphic Rx** icon.
 - ◆ Located in the Additional Parameters area.
7. Prescribe one slice location through the center of the anatomy.
 - ◆ The slice angle, FOV, RBw, and matrix values must be exactly the same as the FGRET series.
8. Click **[Accept]**.
 - ◆ Accepts the prescription and closes the Graphic Rx screen.
9. Click **[Save Series]**.
 - ◆ Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.

10. Click **[Prepare to Scan]**.

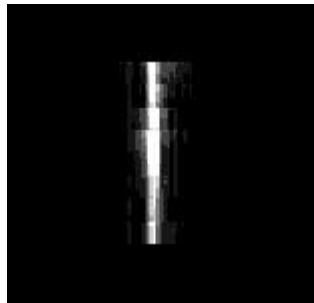
- ◆ Downloads the series.

11. Click **[Scan]**.

- ◆ Auto Prescan is performed and the system initiates the data acquisition with echo tuning mode on.

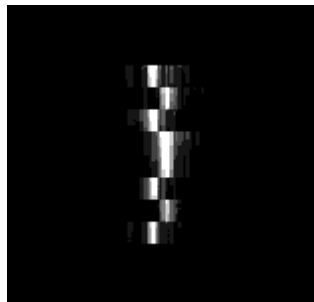
12. Evaluate the images.

- ◆ If the echoes are aligned, continue with step13.



Aligned Echoes

- ◆ If the echoes are misaligned, adjust the echo alignment using the Adjust Echo Alignment for the FGRET-RT Sequence procedure.



Misaligned Echoes

13. Prescribe the FGRET-RT pulse sequence.

- ◆ Refer to the FGRET-RT decision matrix.
- ◆ Set the Manual echo alignment to zero.

Adjust Echo Alignment for the FGRET-RT Sequence

In Brief: Adjust Echo Alignment for the FGRET-RT Sequence

1. Copy and paste the FGRET-RT series used in the Manual Echo Alignment process.
2. Click **[View Edit]**.
3. Click the **User CVs Screen** icon.
4. Enter 1 in the **Echo tuning mode** text box.
5. Enter 6 in the **Echo delay** text box.
6. Enter 1 in **Manual echo alignment** text box.
7. Click **[Accept]**.
8. Click **[Save Series]**.
9. Click **[Prepare to Scan]**.
10. Click **[Scan]**.
11. Evaluate the images.
12. Repeat the acquisition, changing the echo delay each time, until the echoes are aligned as well as possible.
13. Record the value of the optimal echo delay.
14. Prescribe the FGRET-RT pulse sequence.
15. Enter the echo values on the User CVs screen.
16. Scan the FGRET-RT pulse sequence.

Use this procedure if you have performed a manual echo alignment of the FGRET-RT pulse sequence and the echoes are misaligned. Another series must be acquired to adjust the echo alignment. This procedure guides you through the process of adjusting the echo delay to bring the echoes more closely into alignment.

1. Copy and paste the FGRET-RT series used in the Manual Echo Alignment process.
2. Click **[View Edit]**.
 - ◆ Opens the series and allows for changes.
3. Click the **User CVs Screen** icon.
 - ◆ Located in the Additional Parameters area.
 - ◆ The User CVs return to their default state when a new series is selected.
4. Enter 1 in the **Echo tuning mode** text box.
 - ◆ Prompts the system to display a representation of the echoes from which proper alignment can be assessed.
5. Enter 6 in the **Echo delay** text box.
 - ◆ Values from ± 1 to ± 12 .
 - The delay unit is microseconds.
6. Enter 1 in **Manual echo alignment** text box.
 - ◆ Enables manual alignment.
7. Click **[Accept]**.
 - ◆ Accepts the entries and closes the User CVs screen.
8. Click **[Save Series]**.
 - ◆ Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
9. Click **[Prepare to Scan]**.
 - ◆ Downloads the series.
10. Click **[Scan]**.
 - ◆ Auto Prescan is performed and the system initiates the data acquisition with Echo tuning mode on.

11. Evaluate the images.
 - ♦ If the echoes are aligned, continue with step 13.
 - ♦ If the echoes are misaligned continue with step 12.
 12. Repeat the acquisition, changing the echo delay each time, until the echoes are aligned as well as possible.
 - ♦ Continue to repeat steps 1 to 11 to adjust the echo delay value.
 - ♦ Adjust the echo delay in increments of one.
 - This may be a negative value.
 13. Record the value of the optimal echo delay.
 - ♦ This value will be manually entered in a later step.
- NOTE:** If you are unable to align the echoes, contact your service engineer.
14. Prescribe the FGRET-RT pulse sequence.
 - ♦ Refer to the FGRET-RT decision matrix.
 - ♦ The slice locations must be the same obliquity as the location used for the manual echo alignment series.
 15. Enter the echo values on the User CVs screen.
 - ♦ Echo tuning mode = 0
 - Zero is off.
 - ♦ Echo delay = the value determined in step 13.
 - ♦ Manual echo alignment = 1
 - One is on.
 16. Scan the FGRET-RT pulse sequence.
 - ♦ Refer to the FGRET-RT decision matrix.

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Chapter 10

Spiral Pulse Sequences

Introduction

The Spiral pulse sequence is a 2D, Gradient Echo (GRE) or Spoiled Gradient Echo (SPGR) sequence which uses a spiral trajectory to obtain the required data for image creation. There are two types of Spiral imaging available: High-Resolution (Hi-Res) Spiral and Real Time Spiral.

This chapter explains the pulsing components and timing factors directly related to the Spiral imaging pulse sequences. It contains the step-by-step instructions to help you learn how to:

- Prescribe a Hi-Res Spiral Sequence
- Prescribe a Real Time Spiral Sequence

In addition, this chapter answers the following questions:

1. What is Spiral?
2. When would I use a Spiral pulse sequence?
3. What methods can I use to acquire a Spiral pulse sequence?
4. What are the imaging characteristics of a Spiral pulse sequence?
5. Which imaging options can be used with a Spiral pulse sequence?
6. What are some applications for Spiral sequences?

What Do I Need to Know About...

This section presents the concepts necessary to understand imaging with Spiral pulse sequences. Specifically, you need to understand the following concepts:

- Spiral Basics
 - Parameter Selection Effects
 - Peripheral Nerve Stimulation
- High Resolution Spiral
 - Gated Non-Sequential Hi-Res Spiral
 - Gated Sequential Hi-Res Spiral
 - Image Characteristics
 - Associated Imaging Options
 - Applications
- Real Time Spiral
 - Parameter Selection Effects
 - Image Characteristics
 - Associated Imaging Options
 - Applications

Spiral Basics

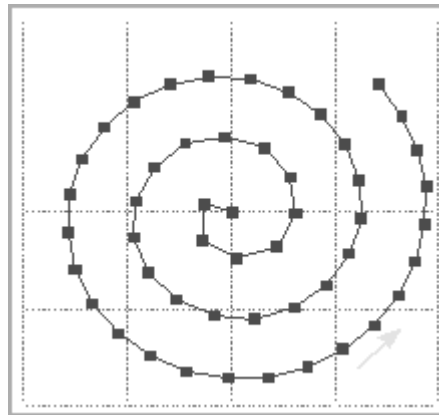
Spiral imaging is a data acquisition method in which K-space is filled in a spiral fashion, as opposed to K-space being filled in a uniform rectilinear grid. Following spiral data collection, the data is interpolated onto a rectilinear grid, which is necessary for applying the Fast Fourier Transform (FFT) for image formation.

The Spiral pulse sequence is a 2D, GRE or SPGR sequence which uses a spiral trajectory to obtain the required data for image creation. A spiral trajectory is obtained by simultaneously applying the gradients in the X and Y directions. By knowing the strength and direction of the gradients at any given time, points within the anatomy can be localized and a gradient echo can be collected.

Spiral imaging provides the following benefits:

- Efficient K-space data collection
 - Filling K-space in a spiral trajectory allows the necessary data to be collected quicker as compared to line-by-line data collection using a rectilinear grid. The outermost corners of K-space are not filled in a spiral trajectory. Figure 10-1 illustrates of a single spiral trajectory.
- Center of K-space is over-sampled
 - This is due to data collection beginning at the center of K-space. This provides an effect similar to multiple averaging of data.
- Relatively short echo times
 - This results from data collection that can begin immediately after radio frequency (RF) excitation.
- Intrinsic flow and motion compensation properties
 - These properties result in images with reduced motion artifacts without the use of flow compensation (FC) or other motion compensation techniques.

Figure 10-1 Single Spiral Trajectory or Arm. This arm contains 50 points of data.



Either a single trajectory or multiple trajectories can be performed in Spiral imaging. The number of trajectories for a sequence is defined as the "number of arms." Each arm contains a defined number of points and each point is a piece of data, which contributes to the filling of K-space. A point is the number of data points that are collected for each spiral arm. The number of arms and points, along with the selected field of view (FOV) and receive bandwidth (RBw) contribute to image resolution. The maximum number of points and arms allowed is based upon Equation 10-1.

Equation 10-1 Maximum Number of Point and Arms

$$\# \text{ of Points} \times \# \text{ of Arms} \times \text{The Decimation Factor} \leq 131,072$$

The decimation factor is based on the prescribed RBw. At 125 kHz, the decimation factor is 1, at 62.5 it is 2, and at 31.25 it is 3. The system displays an error if the selected combination of points, arms, and RBw is unacceptable.

Although these parameters affect resolution, there is not a direct method of calculating resolution based only on these factors. The effective resolution is displayed in the Acquisition Timing area. Effective resolution is based on the acquired resolution and the reconstruction resolution. It is automatically calculated and displayed. Due to the interpolation of the spiral data into a rectilinear grid needed for the FFT, reconstruction times are longer, as compared to many other types of pulse sequences.

The Acquisition Timing area is modified to reflect a spiral acquisition. The **Points** text box replaces Frequency, and **Arms** text box replaces Phase. The **Effective Resolution** text box is displayed in place of the Frequency Direction (there is no frequency direction in a spiral data acquisition) and displays the effective resolution of the prescribed sequence. The **B₀ Maps**

text box is seen in place of Phase Correct. Figure 10-2 displays the modified Acquisition Timing area and Table 10-1 describes the new text boxes.

Figure 10-2 Spiral Acquisition Timing Area

Table 10-1 Spiral Acquisition Timing Selections

Selection	Description
Points	Defines the number of data points that are collected for each spiral arm. The minimum is 512 and the maximum is 8192 (4096 for a multi-array coil), in increments of 2. Points and Arms are annotated in place of the Matrix, e.g., 4096x32/1.00NEX.
Arms	Defines the number of spiral trajectories that are performed. Multiple arms can be interleaved within the same TR, or they can be collected in consecutive TRs; the method used depends on the type of spiral sequence being performed. Increasing the number of arms increases spatial resolution because sampling is taking place further toward the edges of K-space. The minimum is 1 and the maximum is 32, in increments of 1.
Effective Resolution	Shows the effective resolution of the prescribed series in millimeters. This text box is not editable. The Effective Resolution annotation replaces the Frequency direction in the lower right corner of the image, e.g., EffR: 0.51.
B₀ Maps	Compensates for phase differences that result from inhomogeneities by performing a type of phase correction. Turning B ₀ Maps on can improve image quality. Two spiral arms (TRs) are added to an acquisition when B ₀ Maps is on, adding a minimal amount to scan time, thus extending breath-hold acquisition times. When B ₀ Maps is used, it is indicated in the same fashion as Phase Correct. PC is annotated as a prescan option on the Series Text page.

Parameter Selection Effects

The effects of changing sequence parameters in spiral imaging may differ from other pulse sequences, or the effects may be more pronounced. Table 10-2 can be used for reference when setting up a spiral sequence. The parameters in the table are mentioned because of the importance of choosing these factors carefully for spiral imaging.

Table 10-2 Imaging Effects with Spiral Sequences

Parameters	SNR	Spatial Resolution	Scan Time	Image Blurring	Spiral Aliasing (wrap)
↑ RBw	↓	No change or slight ↓	No change	↓	No change
↑ # of Arms	↓	↑	↑	No change	No change
↑ # of Points	↓	↑	No change or slight ↑	↑	No change
↑ FOV	↑	↓	No change	↑	↓
Center Freq off-center	↓	No change	No change	↑	No change

There are several additional factors that affect image contrast:

- Applying a 60° flip angle allows you to maintain a T1 weighted contrast on static tissue, allowing bright flow signal.
- The T2 Prep Imaging Option is a magnetization prep pulse that allows suppression of muscles and venous structures.

There are several factors you should consider when using Spiral sequences:

- Wrap-around (aliasing) can occur in all directions in spiral acquisitions, except in the slice-select direction. Use FOVs large enough to cover the anatomy of interest to avoid this wrap.
- Incorrect coil positioning can result in stimulation of tissue outside the FOV, which results in increased aliasing; therefore, it is important to ensure correct coil positioning over the anatomy of interest.
 - It may be beneficial to use a decreased number of coil elements, when possible, to help decrease the possibility of aliasing from unwanted tissue. For example, the Cardiac Phased Array coil allows selection of either the anterior or posterior coil elements by selecting CARDIAC_ANT or CARDIAC_POST respectively. Turning off un-needed coil elements decreases the possibility of aliasing from unwanted anatomy.

Peripheral Nerve Stimulation

Spiral imaging increases the possibility of Peripheral Nerve Stimulation (PNS). dB/dt refers to the rate of change in magnetic field to time, which is expressed in Tesla/seconds. dB/dt and specific absorption rate (SAR) levels for the patients are based on current scientific literature related to safety, and that the level of exposure shall be a medical judgment as to the patient's potential risk versus benefit.

PNS is described as a light touching sensation felt on various areas of the skin surface. These areas vary, depending upon which gradient axis is in use. Some common areas for the sensation are the bridge of the nose, arms, chest and upper abdomen. Hands clasped together considerably lowers nerve stimulation thresholds and should be avoided. The potential for PNS is low, but it exists for all sequences and gradient configurations.



CAUTION: Patients who complain of PNS during a Spiral sequence should have the series stopped and replaced with another pulse sequence. If the PNS occurs with a non-Spiral sequence, the patient should be removed from the magnet and the incident reported to GE Medical Systems.

PNS is not harmful. The potential for inducing PNS is kept within limitations. In the United States, the system is limited from operating above 66% of the PNS threshold by the software (unless the system is operating in research mode). The point at which 50% of a population will experience PNS is the PNS threshold.

Your MR system is capable of operating under two modes: Clinical mode (normal) and Research mode (proprietary license agreement with GE).

High Resolution Spiral

High Resolution Spiral (Hi-Res Spiral) has been developed to obtain high resolution images in ultra-fast scan times, in seconds and even milliseconds. This sequence is well suited for obtaining images of the coronary arteries.

Hi-Res Spiral acquisitions can be performed in cardiac-gated or non-gated method. To perform a spiral sequence, either Spiral Gradient Echo (GRE) or Spiral Spoiled Gradient Echo (SPGR) is selected on the Pulse Sequence window. Selections on the Imaging Options window further define the type of data to be acquired.

Hi-Res Spiral sequences can be acquired cardiac-gated or non-gated.

- Non-gated Hi-Res Spiral is a 2D, GRE or SPGR sequence.
 - Spiral GRE or Spiral SPGR is selected on the Pulse Sequence window.
 - One or more slice locations can be acquired.
 - Non-gated Hi-Res Spiral is not commonly used due to the nature of the anatomy.
- Gated Hi-Res Spiral is a 2D, GRE or SPGR sequence that is cardiac-gated in the same manner as a FastCard sequence.
 - Two types of gated spiral can be performed: non-sequential and sequential.

Gated Non-Sequential Hi-Res Spiral

In a Gated Non-Sequential Hi-Res Spiral sequence, single-slice or multi-slice imaging is allowed. In multi-slice, the maximum number of slices allowed is based on the heart rate. Only a single cardiac phase can be acquired.

There are three types of Gated Non-Sequential Hi-Res Spiral sequences:

- Single-arm, single-slice acquisition
 - Obtains all the data for the slice in one TR, also called a single-shot. This sequence is rarely performed due to poor image resolution.
- Single-arm, multi-slice acquisition
 - Obtains all the data for all locations in a single R-R interval. Each slice location is acquired in a single shot. This sequence is rarely performed due to poor image resolution.
- Multi-arm acquisition
 - Repeats the data acquisition, which took place in the single-arm acquisition, whether it is single or multi-slice. All slice locations are acquired at the same phase of the cardiac cycle.

Gated Sequential Hi-Res Spiral

Gated Sequential Hi-Res Spiral sequences can acquire single-slice or multi-slice images. Sequential must be selected on the Imaging Options window to perform this sequence. The sequence then allows you to acquire multiple cardiac phases. The number of cardiac phases obtained can be entered manually in the **# of Cardiac Phases to Reconstruct** text box on the Cardiac Gating/Triggering screen. Alternatively, the number of phases acquired can be automatically determined by the system when Auto is selected for the number of cardiac phases to reconstruct.

There are four types of Gated Sequential Hi-Res Spiral sequences.

- Single-arm, single-slice acquisition
 - Obtains all the data for one phase in one TR period, then repeats the data acquisition at subsequent phases within one cardiac cycle.
- Multi-arm, single-slice acquisition
 - Repeats the single-arm sequence to complete the number of arms defined; if six arms are prescribed, the sequence is repeated six times.
- Single-arm, multi-slice acquisition
 - Obtains all the phase data for a single location in one R-R interval. All phases for the next location are obtained in the next R-R interval, and so on, until all slices are complete.
- Multi-arm, multi-slice acquisition
 - Completes all the arms for slice one, collecting all phases for that slice in one R-R interval. All phases and arms are then collected for the next slice, and so on, until all slices are complete.

For multi-slice acquisitions, if a negative spacing (overlap) is prescribed, the slice locations are acquired in an interleaved fashion to avoid cross-talk. Otherwise, acquisition slice ordering is done sequentially. Reducing the flip angle from 60° to 45° for gated sequential acquisitions reduces saturation effects and improves SNR.

In gated sequences, extend the trigger delay (TD) to a point at which mid-diastole is taking place (commonly 350 to 450 ms) to obtain images during the most quiescent part of the cardiac cycle. Another benefit of obtaining image data at mid-diastole is flow is maximized at this time.

Image Characteristics

Spiral imaging produces images with high spatial and temporal resolution. The pulse sequences are annotated “GR/SPIRAL/20” or “SPGR/SPIRAL/20” with 20 indicating the flip angle.

Figure 10-3 Hi-Res Spiral Image of the Coronary Artery



Associated Imaging Options

Imaging Options provide image processing or filters for enhancing anatomical features or reducing noise. In Table 10-3, the Xs indicate the imaging options available for use with the Hi-Res Spiral pulse sequence.

Table 10-3 Hi-Res Spiral Pulse Sequence Imaging Options

Imaging Options			
	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel		Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer	X	Sequential
X	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF		IR Prepared
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station		Real Time
X	T2 Prep	X	Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

Two primary imaging options are available for Spiral imaging.

- Spectral Spatial RF (SSRF) uses slice-selective pulses to suppress signal from fat.
 - This can be especially useful for suppressing the fat that may interfere with visualization of the coronary arteries.
- T2 Prep applies a sequence of non-selective 90° and 180° RF pulses to suppress tissue.
 - This can be used to decrease signal from surrounding venous structures and lessen signal from tissue such as cardiac muscle.

There are several factors you should consider when using the imaging options with Hi-Res Spiral sequences:

- When FC is used, it is applied in the slice-select direction only.
- Sequential can only be used in the gated mode and is required for multiple cardiac phases.
- The RBw is limited to 31.25, 41.67, 62.5, and 125 kHz.
 - When the number of points is prescribed to 2048 or greater, the RBw must be set to 125 kHz.

In addition, Hi-Res Spiral is also compatible with the following options:

- Phased array
- Fat and water suppression
 - Not allowed with SSRF
- Spatial SAT
 - Not allowed with T2 Prep

Applications

Spiral imaging is intended for whole body imaging and is capable of producing images with high spatial and temporal resolution, such as fine structures where motion can be a problem. Examples include:

- Cardiac Gated Hi-Res Spiral can be used to image the coronary arteries.
- Single-slice, Multi-phase Cardiac Gated Hi-Res Spiral can be used to capture in plane, multiple cardiac phases of a single coronary artery.
- Visualization of the coronaries may be improved with the use of SSRF.
- T2 Prep can be used to decrease signal from venous structures.



WARNING: The system cardiac gating waveforms are not to be used for physiologic monitoring. The patient's condition may not be reflected, resulting in improper emergency medical treatment.

Real Time Spiral Imaging

Real Time Spiral Imaging is used with the *i*Drive Pro Plus Real Time Cardiac Acquisition (RTCA) imaging feature. Real Time Spiral acquisitions are defined by selecting either Spiral GRE or Spiral SPGR on the Pulse Sequence window and Real Time on the Imaging Options window. As in any *i*Drive RTCA prescription, only one location is prescribed for this sequence.

The following are key components of Real Time Spiral:

- All coil types are allowed.
- Cardiac Gating/Triggering is not allowed.
 - The Real Time Spiral frame-rate is typically described in frames per second (FPS) providing high-temporal resolution images exhibiting little or no motion in areas such as the heart.
- Real Time Spiral images are of low spatial resolution, so this sequence is typically used for localization of anatomy.
- The prescribed number of points affects the maximum number of arms allowed. Likewise, the number of arms affects the maximum number of points allowed.
- The Imaging Option SSRF is available with Real Time Spiral.
 - SSRF can be used to suppress signal from fat. This can be especially useful for suppressing the fat that may interfere with visualization of the coronary arteries.

NOTE: Refer to the Imaging with Real Time chapter in this guide for additional information on *i*Drive Pro Plus.

Parameter Selection Effects

Real Time Spiral is compatible with the following selections.

- Phased array
- RBw limited to 62.5 and 125 kHz
- Fat suppression
- B₀ Maps

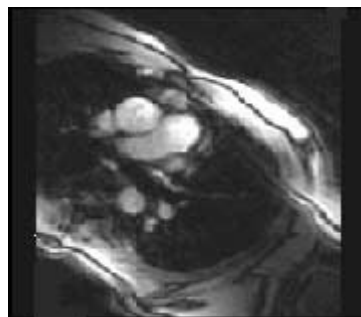
In addition, there are several factors you should consider when using Real Time Spiral:

- If B_0 Maps is desired, it must be turned on in the Acquisition Timing area during series prescription and cannot be turned on/off at the *i*Drive Pro Plus Acquire tab.
 - B_0 Maps is annotated on the Series Text page as PC.
- When B_0 Maps is turned on during series prescription, the displayed FPS value is indicative of the frame rate during the point in data acquisition when the B_0 Map function is performed.
 - The actual frame rate (when B_0 Maps is not being performed) is likely to be higher.
- If the effective resolution (which is based on the points, arms and RBw) is below the value resulting from the FOV (in mm) divided by 128, the system requires a change in either points, arms, or RBw.
- If the FOV (in mm) divided by 128 is greater than the calculated effective resolution, the resulting image resolution is based on the equation, not the effective resolution.
 - $\text{FOV (in mm)} \div 128 = \text{Pixel size}$
- Fat suppression must be turned on during series prescription and cannot be turned on/off at the *i*Drive Pro Plus Acquire tab.
- Spatial SAT pulses are not allowed.

Image Characteristics

Real Time Spiral is a low spatial resolution sequence. The pulse sequence is annotated “GR/SPIRAL/20” or “SPGR/SPIRAL/20” with 20 indicating the flip angle. The images are not annotated to show that Real Time was selected on the Imaging Options window.

Figure 10-4 Real Time Spiral Image



Associated Imaging Options

Imaging Options provide image processing or filters for enhancing anatomical features or reducing noise. In Table 10-4, the Xs indicate the imaging options available for use with the Real Time Spiral pulse sequence.

Table 10-4 Real Time Spiral Pulse Sequence Imaging Options

Imaging Options			
	None	X	Variable Bandwidth
	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel		Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer		Sequential
	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF		IR Prepared
	DE Prepared		Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024		ZIP 512
	Zip x 2		ZIP x 4
	SmartPrep		Blood Suppression
	Multi Station	X*	Real Time
	T2 Prep	X**	Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

NOTE: *Real Time must be selected to acquire Real Time Spiral images.

NOTE: **SSRF must be turned on during series prescription on the Imaging Options window and cannot be turned on/off at the iDrive Pro Plus Acquire tab.

Applications

Real Time Spiral can be used for the quick localization of anatomy lying in double-oblique planes and in areas where motion can be a problem, such as the coronary arteries.

How Do I...

This section provides the step-by-step instructions for prescribing Spiral imaging pulse sequences. Specifically, it describes how to:

- Prescribe a Hi-Res Spiral Sequence
- Prescribe a Real Time Spiral Sequence

Decision Matrix

A decision matrix is used in this section to provide examples of what values could be selected for prescribing a particular sequence. The purpose of the decision matrix is to help you understand the trade-offs that occur when you change the values for a particular parameter and to provide a framework with which you may build your own unique protocol.

The example protocols provide information on what could be used for these pulse sequences and are not to be considered recommendations by GE Medical Systems. For specific protocols, refer to the protocols on your system.

In addition to listing the information you need to select on the system, the “What You Select” column of the matrix uses two other conventions.

- N/A indicates that the imaging parameter is not applicable to the pulse sequence example.
- N/S indicates that the imaging parameter is not selectable in the pulse sequence example. The system automatically selects these imaging parameters.



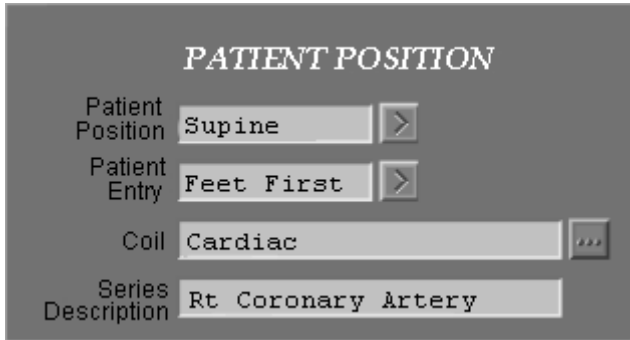
CAUTION: Provide all patients with ear protection prior to any scan to help avoid possible hearing impairment. Acoustic noise levels can exceed 99 dbA in the magnet bore.

Prescribe a Hi-Res Spiral Sequence

The Hi-Res Spiral sequence is useful in clinical applications to obtain high-resolution images in ultra-fast scan times. This sequence is well suited for acquiring images of the coronary arteries. Visualization of the coronaries may be improved with the use of T2 Prep and SSRF.

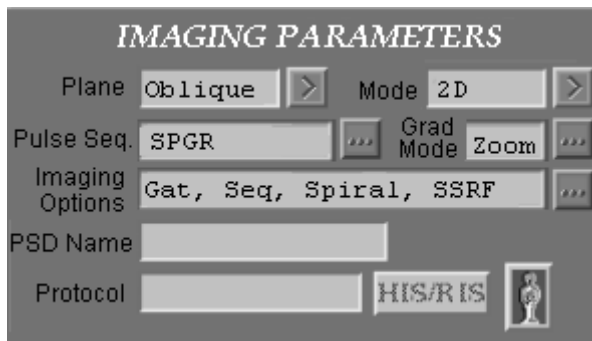
The decision matrix (Table 10-5) is only for prescribing a Hi-Res Spiral scan with cardiac gating. The following example protocol is for prescribing an oblique right coronary artery cardiac scan for a TwinSpeed or an EchoSpeed system.

Table 10-5 Hi-Res Spiral Protocol Example (Right Coronary Artery)

Hi-Res Spiral Protocol Example		
What You Select	Selection Notes	
Scan Rx Desktop		
Scan Rx	Acquire a localizer series	Allows Graphic Rx to become available so you can prescribe slices graphically on the localized image.
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol screen becomes active.
Patient Position		
		
Patient Position	Supine	Indicates the orientation of the patient. Although compatible with any patient position and entry, supine and feet first are recommended. This ensures accurate cardiac gating/triggering and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	

Hi-Res Spiral Protocol Example

What You Select		Selection Notes
Coil	Phased Array > Cardiac	Allows selection of the coil from which the signal is transmitted and received. Use a coil that produces the optimum coverage and SNR. Up to a four-coil phased array coil is allowed. Note that two additional configurations are available for the Cardiac PA coil. CARDIAC_ANT and CARDIAC_POST turn on the two coil elements in the anterior and posterior portion of the cardiac coil, respectively. CARDIAC_ANT can be used to reduce signal from posterior anatomy, thus reducing the potential for aliasing from the spine and back in spiral acquisitions. These selections are available from the Phased Array coil list.
Series Description	Enter a series description in the text box.	Allows you to enter a brief description of the series being prescribed. If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

Imaging Parameters


Plane	Oblique	Defines the scan plane of the acquisition. Compatible with any scan plane. Select the plane that best meets your clinical need. Oblique is generally used to obtain the proper angle through the heart.
Mode	2D	Prescribes a two-dimensional sequence.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	Spiral SPGR	Prescribes a Spiral SPGR pulse sequence. Spiral GRE is also an allowable selection.
Imaging Options	Cardiac Gating Triggering, Sequential, and Spectral Spatial RF	Provides appropriate options for enhancing anatomical features and reducing noise. Cardiac Gating/Triggering and Sequential allow a gated sequence with multiple cardiac phases. Select Sequential for a single cardiac phase acquisition and do not select for a multiple phase cardiac acquisition. This sequence can also be acquired without cardiac gating. SSRF can be used to suppress signal from fat that may interfere with visualization of the coronary arteries. Select T2 Prep to diminish signal from tissue such as muscle and venous structures. Use of T2 Prep dramatically reduces SNR.

Hi-Res Spiral Protocol Example		
What You Select		Selection Notes
PSD Name	N/A	
Protocol	N/A	

Scan Timing



# of echoes	N/S	One echo is selected automatically.
TE	Minimum	The only TE available selection is minimum.
TE2	N/A	
TR	N/S	The minimum TR is used to maintain ultra-fast scan times.
Inv Time	N/A	
T12	N/A	
Flip Angle	60	The typical flip angle value is 60°. Decrease the flip angle to 45° for sequential acquisitions to reduce saturation effects.
Echo Train Length	N/A	
Bandwidth	125.00	The RBw values allowed are 31.25, 41.67, 62.5, and 125 kHz. Typical values are 62.5 and 125 kHz. The systems selects one of the four values closest to the typed-in value. Increasing the RBw results in decreased SNR, decreased image blurring, and a slight decrease in spatial resolution. The bandwidth must be set to 125 kHz when the number of points is 2048 or greater.
Bandwidth2	N/A	

Hi-Res Spiral Protocol Example

What You Select

Selection Notes

Scanning Range

SCANNING RANGE

		A/P	S/I Center	R/L Center
FOV	24	Start		
Slice Thickness	5	End		
Spacing	0.0	# Slices		

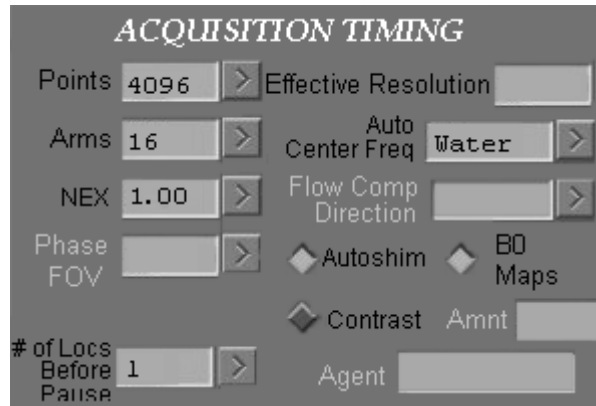
FOV	24	Defines the size of the area imaged. Select an FOV that covers the anatomy of interest, about 20 to 40 cm. Anatomy outside the FOV results in spiral aliasing. As the FOV decreases, SNR decreases, spatial resolution increases, and image blurring decreases.
Slice Thickness	5	Defines the thickness of the image slice. A slice thickness of 3 to 5 mm is generally used. As the slice thickness decreases, SNR decreases.
Spacing	Enter 0.0 in the text box.	Places a zero spacing between the prescribed slice locations. Zero spacing or even a negative spacing is commonly used. A negative spacing, e.g., -2.5, is allowable, up to 50% of the slice thickness. When a negative spacing is prescribed, slice-ordering is performed in an interleaved fashion to minimize cross-talk. Note that cardiac vessels may be more successfully captured with sequential slice ordering.
Start, End Locations		Determines the start and end locations from the Graphic Rx program after the slices are prescribed and posts the locations here.
# Slices		Determines the number of slices as prescribed in Graphic Rx and posts it here. Adjust the number of slice locations as necessary.

Hi-Res Spiral Protocol Example

What You Select

Selection Notes

Acquisition Timing



Points	4096	Defines the number of data points to be collected for each spiral arm. The typical values are 2048 to 4096 points. As the number of points increases, spatial resolution increases as indicated by the smaller effective resolution. As pixel size gets smaller, SNR decreases as indicated by the SNR meter. The prescribed number of arms and RBw affect the maximum number of points allowed.
Arms	16	Defines the number of spiral trajectories to be performed. The typical values are 16 to 24 arms. Increasing the arms and the RBw affect the maximum number of arms allowed.
NEX	1	Low NEX values are generally used to maintain ultra-fast scan times. As NEX increases, SNR and scan time increase.
Phase FOV	N/A	
Effective Resolution	N/S	Calculates the effective resolution by the system and posts it here in millimeters. This text box is non-editable. Effective resolution is displayed when the FOV, arms, points, and RBw are defined.
Auto Center Freq	Water	Sets this CF peak during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Improves image quality and is recommended for this sequence.
B ₀ Maps	On	Improves image quality and corrects for phase differences that result from field inhomogeneities. The use of B ₀ Maps adds to the total scan time, but is recommended.
# of Locs Before Pause	1	Allows for breath-hold acquisitions. If acquiring the slices sequentially, use one location per breath-hold.

Hi-Res Spiral Protocol Example

What You Select

Selection Notes

Additional Parameters - Gating/Triggering

CARDIAC GATING/TRIGGERING

Trigger Type Auto

of RR Interval

Arrhythmia Rejec. Window Auto

Trigger Delay

Inter-Seq Delay

Cardiac Phases Single Multi

Phases

Slices

of Card. Phases to Reconstruct Auto

Views per Segment

Heart Rate

Trigger Type	Select the best lead.	Defines which signal is sent by the cardiac monitor to activate the data acquisition. When ECG gating, select the lead that provides the best signal. Peripheral gating is not recommended.
# of R-R Interval	N/A	
Arrhythmia Rejec. Window	20	Defines the window size, as a percentage of the R-R interval, outside of which the system rejects data if a trigger is detected. Values around 20% are most commonly used to allow reasonable latitude. If the patient's heart rate is irregular, increase this value and the TW, then the time available to collect the data will decrease.
Trigger Delay	Enter 450 in the text box.	Defines the delay time between the occurrence of the triggering pulse and the actual onset of imaging. Values between 350 and 450 are most common. In addition to manually entering a value, the minimum and recommended choices can also be selected. Increasing the TD decreases the maximum number of slices allowed.
Inter-Seq Delay	Minimum	Defines the time between each image in the cardiac cycle. Minimum or Even spacing are the choices.
Cardiac Phases	N/A	
# of Card. Phases to Reconstruct	Auto	Collects the maximum number of phases available automatically. The number of cardiac phases can also be entered manually in the text box.
Views per Segment	N/A	

Hi-Res Spiral Protocol Example		
What You Select		Selection Notes
Heart Rate	[update Rate]	Lets the system obtain an automatic reading of the current heart rate. Updates the rate prior to beginning the scan.
Accept	[Accept]	Confirms the selected values and closes the Gating/Triggering Additional Parameter screen.

Additional Parameters - Graphic Rx



[+] Next and [-] Prior	[+] and [-]	Allows you to page through the localizer images to check the position of the prescription.
Image Viewport	Click the image to display the line cursor.	Prescribes slices for graphic prescription. Select the adjustment handles to angle, draw, and remove slices. Position the slices to cover anatomy of interest and view the Advisory Panel to note the maximum number of slices per acquisition and the number of acquisitions you are prescribing. The scan time increases as the number of acquisitions increase.
Copy Rx	[Copy Rx] (optional)	Copies the exact locations of the prior series if you had previously graphically prescribed a series with the same plane, FOV, and slice thickness.
Erase All	[Erase All] (If necessary)	Eliminates the graphic prescription from the screen and allows you to start over.
Reset Center	[Reset Center] (If necessary)	Re-establishes the FOV center on a different localized slice.
Accept	[Accept]	Confirms the cursor position and closes Graphic Rx.

Series Control

Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
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Rx Manager

Prepare to Scan	[Prepare to Scan]	Downloads the series.
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Scan Operations

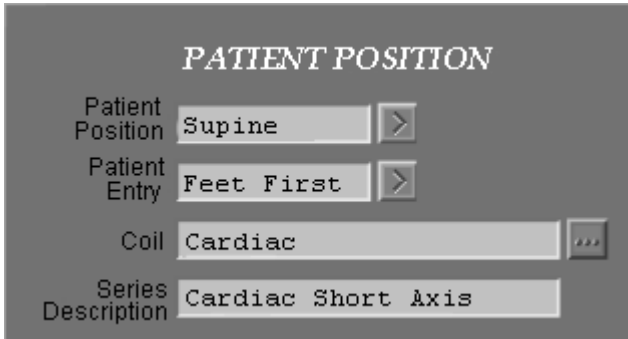
Prep Scan	[Prep Scan]	Performs Auto Prescan and readies the system for data acquisition. Select for breath-hold acquisitions.
Scan	[Scan]	Initiates the acquisition. Instruct the patient to hold his/her breath as long as possible, until the scan stops, if able.

Prescribe a Real Time Spiral Sequence

The Real Time Spiral sequence is performed using *i*Drive Pro Plus to obtain real time image data with interactive scan plane manipulation. This is useful to quickly obtain localizer images and locations for imaging cardiac anatomy, as well as, other areas of the body.

The decision matrix (Table 10-6) is only for prescribing a Real Time Spiral scan. The following example protocol is for prescribing an oblique short axis cardiac scan for a TwinSpeed or an EchoSpeed system.

Table 10-6 Real Time Spiral Protocol Example (Short Axis Cardiac)

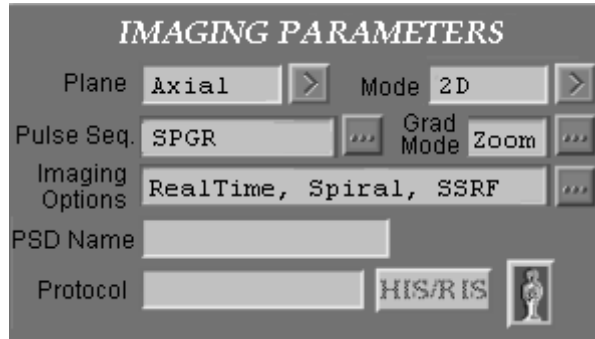
Real Time Spiral Protocol Example		
What You Select	Selection Notes	
Rx Manager		
Rx Manager	[New Series]	Adds an additional series to the patient's exam.
Patient Protocol	[Patient Position]	Allows you to begin prescribing your new series if the Patient Protocol screen becomes active.
Patient Position		
		
Patient Position	Supine	Although compatible with any patient position and entry, supine and feet first are recommended. This ensures accurate cardiac gating/trigging and patient safety by ensuring proper routing of gating cables out of the bore, and proper routing of the coil cable to its attachment point on the dog-house.
Patient Entry	Feet First	
Coil	Phased Array > Cardiac	Use a coil that produces the optimum coverage and SNR. Up to a four-coil phased array coil is allowed. As the number of coils increases, the frame rate decreases.
Series Description	Enter a series description in the text box.	If you do not enter a description, the system enters one for you. The series description default is the selected scan mode, PSD, and selected imaging options.

Real Time Spiral Protocol Example

What You Select

Selection Notes

Imaging Parameters



Plane	Axial	Only orthogonal planes are allowed during series prescription. Any plane can be obtained from the Pro Plus Acquire tab.
Mode	2D	Prescribes a two-dimensional sequence. 2D is the only mode allowed.
Grad Mode	Zoom	Activates the gradient mode of operation. This text box is only available if your system has Twin gradients.
Pulse Sequence	Spiral SPGR	Prescribes a Spiral SPGR pulse sequence. Spiral GRE is also an allowable selection for Real Time Spiral.
Imaging Options	Real Time, Spectral Spatial RF	Real Time enables Real Time Spiral. SSRF eliminates signal from fat. SSRF decreases the frame rate.
PSD Name	N/A	
Protocol	N/A	

Real Time Spiral Protocol Example

What You Select

Selection Notes

Scan Timing

SCAN TIMING

of Echoes 1 2 4

TE

TE2

TR

T1

TI2

Flip Angle

Echo Train Length

Bandwidth

Bandwidth2

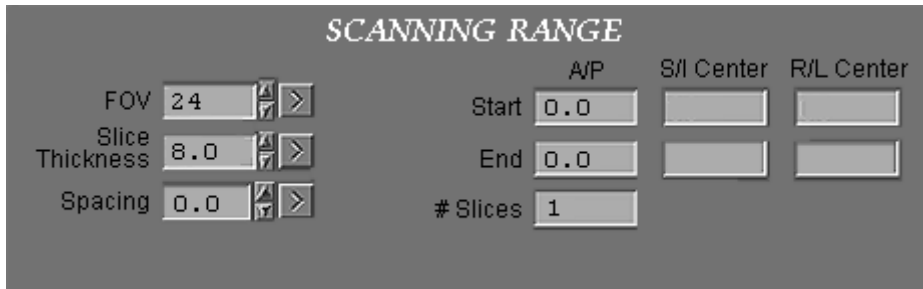
# of echoes	N/S	One echo is selected automatically.
TE	Minimum	The only TE selection available is minimum.
TE2	N/A	
TR	Minimum	The minimum TR is recommended to maintain ultra-fast scan times. Selections available include minimum, 70, 80, 90, and 100.
T1	N/A	
TI2	N/A	
Flip Angle	30	The typical flip angle value is between 25° and 30°. Large flip angles are likely to result in tissue saturation.
Echo Train Length	N/A	
Bandwidth	62.50	As the RBw increases, SNR decreases, spatial resolution decreases slightly, and image blurring decreases as a result of shorter echo spaces. 62.5 and 125 kHz are allowed.
Bandwidth2	N/A	

Real Time Spiral Protocol Example

What You Select

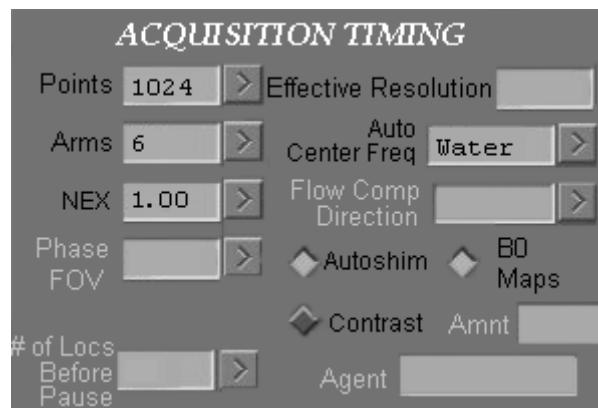
Selection Notes

Scanning Range



FOV	24	Defines the size of the area imaged. Select an FOV that covers the anatomy of interest, about 24 to 32 cm. Anatomy outside the FOV may result in spiral aliasing. Small FOVs produce increased resolution, decreased SNR, and may decrease image blurring. Large FOVs may decrease the minimum TR and thus increase frame rate.
Slice Thickness	Enter 8.0 in the text box.	Defines the thickness of the image slice. A value of 5 to 8 mm is typically used.
Spacing	Enter 0.0 in the text box.	A single slice is prescribed for the real time series. Spacing can be zero.
Start, End Locations	Enter 0.0 in the text boxes.	Prescribes a single slice location prescription explicitly. Graphic Rx can also be used to prescribe the slice location.
# Slices	1	Only one slice location is allowed for real time sequences.

Acquisition Timing



Points	1024	Defines the number of data points to be collected for each spiral arm. As the number of points increases, spatial resolution increases as indicated by the smaller effective resolution. As the pixel size gets smaller, the SNR decreases as indicated by the SNR meter. FPS decreases.
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Real Time Spiral Protocol Example		
What You Select		Selection Notes
Arms	6	Defines the number of spatial trajectories to be performed. Increasing the arms results in increased SNR, increased scan time, and increased spatial resolution, but the FPS decreases.
NEX	1	One NEX is generally used to maintain ultra-fast scan times. As NEX increases, SNR, and scan time increase.
Phase FOV	N/A	
Effective Resolution	N/S	Calculates the resolution and posts it here in millimeters. The Effective Resolution is a non-editable text box. Effective resolution is displayed when the FOV, arms, points, and RBw are defined.
Auto Center Freq	Water	Sets this CF peak during prescan.
Flow Comp DIR	N/A	
Autoshim	On	Improves image quality and is recommended for this sequence.
B ₀ Maps	On	Improves image quality. With B ₀ Maps on, the displayed FPS is the frame rate when B ₀ Maps is being performed. The actual frame rate is likely to be greater than the displayed value.
# of Locs Before Pause	N/A	
Series Control		
Save Series	[Save Series]	Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
Rx Manager		
Prepare to Scan	[Prepare to Scan]	Downloads the series.
Scan Operations		
Scan	[Scan]	Initiates Auto Prescan and the <i>i</i> Drive Acquire tab opens. Home images are acquired and at this point, the Acquire tab can be used to navigate through the anatomy and alter image contrast as needed. Scan planes and slice locations can be copied from the <i>i</i> Drive window to a series in the Rx Manager.

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Chapter 11

Bolus Triggering

Introduction

Bolus Triggering is a technique, used in imaging vasculature, where a bolus of a contrast medium activates the scan and is sequentially imaged as it moves through the vessels. It can be performed using the Fluoroscopic Triggered Magnetic Resonance Angiography (FT MRA) option.

This chapter explains the Bolus Triggering process. The focus is on bolus detection and acquisition triggering for contrast-enhanced Magnetic Resonance Angiography (CEMRA). It contains key concepts as well as step-by-step instructions to help you learn how to:

- Scan with Fluoroscopic Triggered MRA
 - Set up a FT MRA series
 - Place Imaging Volume
 - Scan the Series

NOTE: FT MRA is a purchasable imaging option.

In addition, this chapter answers the following questions:

1. Which pulse sequence(s) are compatible with FT MRA?
2. What is FT MRA?

What Do I Need to Know About...

This section presents the concepts necessary to successfully complete the Bolus Triggering process. Specifically you need to understand:

- Description of Fluoroscopic Triggered MRA
 - Associated Imaging Options
 - Applications

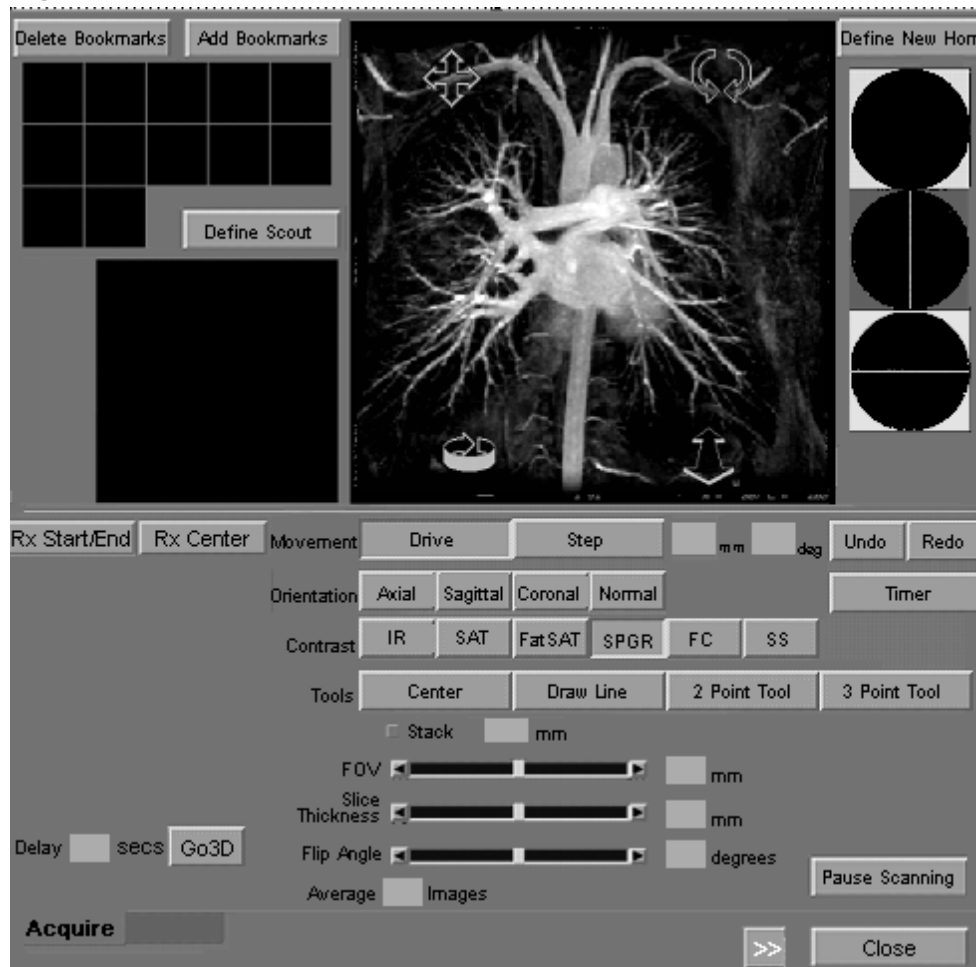
Description of FT MRA

FT MRA is a technique that uses a thick slab, two-dimensional (2D) real time acquisition and reconstruction to monitor the region of interest. FT MRA is used to detect the arrival of a contrast bolus. You will trigger the Elliptic-centric view ordered acquisition of the 3D volume of interest once the vessels have sufficiently enhanced. The 3D acquisition is perfectly synchronized to the peak concentration of contrast in the vessels. Images are annotated **FTx** in the lower left hand corner.

Elliptic-centric K-space filling is defaulted on. This option is located under the **User CVs** icon in the Additional Parameters area. Refer to the Elliptic-centric section of this chapter for additional information regarding this type of K-space filling.

Unlike SmartPrep, FT MRA relies on you to trigger the acquisition, once the bolus is detected. It incorporates Real Time Imaging so that the contrast is visually seen within the vessel before the acquisition is started. Once the acquisition is downloaded and **[Scan]** is selected, you are in the FT MRA mode (Figure 11-1). This screen looks and operates much like the Real Time imaging screen.

Figure 11-1 FT MRA Mode



There are five main differences between the FT MRA imaging mode and the Real Time imaging mode screens.

- **[Pause When Full]** — no longer available.
- **[Save Image]** — no longer available.
- Review tab — no longer selectable.
- Delay text box — system delay value annotated in seconds. Value defaults to delay set by the prescribed acquisition. This value can be changed and a new value can be typed in. The delay period is the time after Go 3D is clicked and the scan actually starts.
- **[Go3D]** — initiates the prescribed acquisition. This button remains active when real time scanning is in progress. If **[Pause Scanning]** is selected, the **[Go3D]** option becomes inactive.

NOTE: Refer to the Real Time Imaging chapter in Volume 4 for explanation of other options present on the screen.

Associated Imaging Options

There are several imaging options that can be used in conjunction with Fluoro Trigger. In Table 11-1, the Xs indicate the imaging options compatible with SmartPrep.

Table 11-1 Fluoro Trigger Compatible Imaging Options

Imaging Options			
X	None	X	Variable Bandwidth
	Flow Compensation	X	No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel		Surface Coil Intensity Correction
	Respiratory Compensation		Classic
	Magnetization Transfer		Sequential
	Cardiac Gating/Triggering		Respiratory Gating/Triggering
	Tailored RF		IR Prepared
	DE Prepared	X	Multi-Phase
	Full Echo Train		CCOMP
X	ZIP 1024	X	ZIP 512
X	Zip x 2	X	ZIP x 4
	SmartPrep		Blood Suppression
X	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF
	Phase Sensitive		Fluoro Trigger

Applications

Use FT MRA when SmartPrep is not optimal. An example of this is when a patient has slow cardiac output or if delayed imaging enhancement is desired. FT MRA is also recommended for performing T1 Post Contrast Liver exams.

How Do I...

This section provides the step-by-step instructions for bolus triggering. Specifically, it describes how to:

- Scan with Fluoroscopic Triggered MRA
 - Set up a FT MRA Series
 - Place Imaging Volume
 - Scan the Series

Scan with Fluoroscopic Triggered MRA

Set Up a FT MRA Series

In Brief: Set Up a FT MRA Series

1. Select the appropriate coil.
2. Position the patient comfortably and immobilize the area of interest with sponges.
3. As directed by physician, set-up the patient IV catheter, and prepare the power injector (optional).
4. Landmark the patient.
5. Press **[Move to Scan]**.
6. Acquire an appropriate localizer series.
7. Click **[New Series]**.
8. Click the **Pt. Position** icon.
9. Select **Plane > Oblique**.
10. Click **Mode > 3D**.
11. Select **Pulse Sequence > Fast TOF GRE** or **Fast TOF SPGR** pulse sequence.
12. Select **Fluoro Trigger**.
13. Complete the scan prescription.
14. Click the **User CVs Screen** icon.
15. Complete **User CVs Screen** parameters.

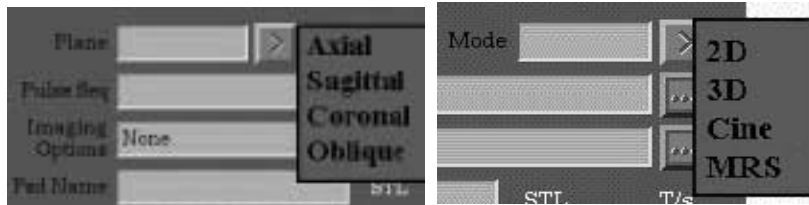
Use this procedure to setup a FT MRA series. By using FT MRA, the system allows you to scan the prescribed acquisition once contrast has been detected by you. This make bolus detection easier, if use of SmartPrep is not available or optimal.

You should already know how to set-up a protocol for your system; only a brief review is explained. The rest of the procedure guides you through the FT MRA setup process.

1. Select the appropriate coil.
 - ◆ Refer to the Gradient, Shim and Imaging Coil chapter in Volume 1 for suggested coil positioning.
2. Position the patient comfortably and immobilize the area of interest with sponges.
3. As directed by physician, set-up the patient IV catheter, and prepare the power injector (optional).
 - ◆ Follow your physician's or facility's guidelines.
4. Landmark the patient.
5. Press **[Move to Scan]**.
 - ◆ This moves the patient to the landmarked location inside the scanner bore.
6. Acquire an appropriate localizer series.
 - ◆ Sometimes more than one localizer is needed to make sure proper volume coverage is included.
7. Click **[New Series]**.
8. Click the **Pt. Position** icon.
 - ◆ Located on the **Scan Desktop**.
9. Select **Plane > Oblique**.
 - ◆ Located in the Patient Position area.

10. Select **Mode > 3D**.

- ◆ Located in the Patient Position area.



Pt. Position area of Scan Desktop

NOTE: You can prescribe a coronal orthogonal plane. Make sure the volume includes the necessary imaging anatomy.

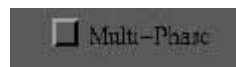
11. Select **Pulse Sequence > Fast TOF GRE or Fast TOF SPGR**.

- ◆ Located in the pulse sequences window.

12. Select **Fluoro Trigger**.

- ◆ Located in the imaging options window.

NOTE: Select **Multiphase** to capture both the arterial and venous phase. Refer to Imaging Options chapter in Volume 4, for additional information.



13. Complete the scan prescription.

- ◆ Select the scan timing parameters to minimize TR and TE.
- ◆ Select FOV, matrix and slice thickness to balance spatial resolution and SNR.
- ◆ Minimize scan time to allow for breath-held acquisitions.

NOTE: Remember to enter the correct contrast dosage. Refer to Threshold section for more detailed information.

14. Enter the SmartPrep Imaging Parameters under the **User CVs Screen** icon.

- ◆ Located in the Additional Parameters area.

15. Complete **User CVs Screen** parameters.

Scan with Fluoroscopic Triggered MRA Place Imaging Volume

In Brief: Place Imaging Volume

1. Click the **Graphic Rx** icon.
2. Select appropriate series and image.
3. Click on the image to place your 3D imaging volume.
4. Adjust the angle of the volume to ensure proper coverage of anatomy.
5. Click **[Fallback]** if necessary.
6. Click **[Accept]**.
7. Click **[Save Series]**.

Use this procedure to place the FT MRA imaging volume. The set up of the FT MRA series steps must be done prior to placing the imaging volume.

1. Click the **Graphic Rx** icon.
2. Select appropriate series and image.
3. Click on the image to place your 3D imaging volume.



Example of an imaging volume placed on a midline slice.

- ◆ A midline slice is best for setting up your imaging volume, unless your patient is off center inside the magnet.
4. Adjust the angle of the volume to ensure proper coverage of anatomy.
 - ◆ The angle can only be adjusted in the oblique plane.
 5. Click **[Fallback]** if necessary.
 - ◆ This allows your imaging volume center to be set at R0.
 6. Click **[Accept]**.
 - ◆ Closes the Graphic Rx screen.
 7. Click **[Save Series]**.
 - ◆ Closes the scan prescription screen.
 - ◆ Accepts the scan prescription.
 - ◆ Saves it in the Rx Manager as RXD.

Scan with Fluoroscopic Triggered MRA

Scan the Series

Use this procedure to scan the FT MRA series. The set up of the FT MRA series and the placing of the imaging volume steps must be done prior to scanning the series.

1. Click **[Prepare to Scan]**.
2. Click **[Auto Prescan]**.
3. Click **[Scan]**.
 - ◆ Initiates the acquisition in the FT MRA mode.
4. Adjust the real time image.
 - ◆ Use the real time controls.
 - ◆ Visualize the best possible midline slice of the vessel.
5. Enter Delay value, if necessary.
 - ◆ The delay time should be sufficient enough to allow the patient time to hold breath.
 - ◆ Recommended delay times is 5 seconds or less.
6. Begin administering contrast to the patient.
 - ◆ The amount of contrast should be determined by your physician or facility personnel.
 - ◆ Contrast can be administered by either a power injector or hand bolus.
7. Watch for the bolus on the FT MRA viewer. Click **[Go3D]**, once bolus fills vessel.
 - ◆ This enters the quiet delay period. The count-down can be observed from the PC monitor or from the magnet cover.
 - ◆ Once delay timer reaches one second the system will automatically switch into scanning mode.
 - ◆ FT MRA screen disappears, **Scan Desktop** is again displayed.
 - ◆ Once the system switches into scanning mode, an audible switch of the gradients can be heard.

In Brief: Scan the Series

1. Click **[Prepare to Scan]**.
2. Click **[Auto Prescan]**.
3. Click **[Scan]**.
4. Adjust the real time image.
5. Enter Delay value, if necessary.
6. Begin administering contrast to the patient.
7. Watch for bolus on the FT MRA viewer. Click **[Go3D]**, once bolus fills vessel.

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Chapter 12

Bolus Chasing

Introduction

Bolus Chasing is a technique, used in imaging a bolus of contrast as it travels through the vessels. It is usually performed in conjunction with a bolus triggering technique.

This chapter explains the automated multi station technique for contrast enhanced peripheral vascular angiography. It contains the step-by-step instructions to help you learn how to:

- Scan with SmartStep
 - Patient Preparation
 - Scan the Localizer Series
 - Scan the SmartStep Series

In addition, this chapter answers the following questions:

1. What is SmartStep used for?
2. What is a meta-series?
3. How does elliptic-centric K-space filling affect image contrast?
4. What is Turbo mode?
5. How do I prescribe a mask series
6. Why would you want to prescribe a mask series?

What Do I Need to Know About...

This section presents the concepts necessary to successfully complete the SmartStep process. Specifically you need to understand:

- Description of SmartStep
- Contrast Mechanism
- SmartStep User Control Variables (User CVs)
 - Meta-series
 - Image Acquisition Delay
 - Turbo Mode
 - SPECTral Inversion At Lipids (SPECIAL)
 - K-space
 - Acquisition Type

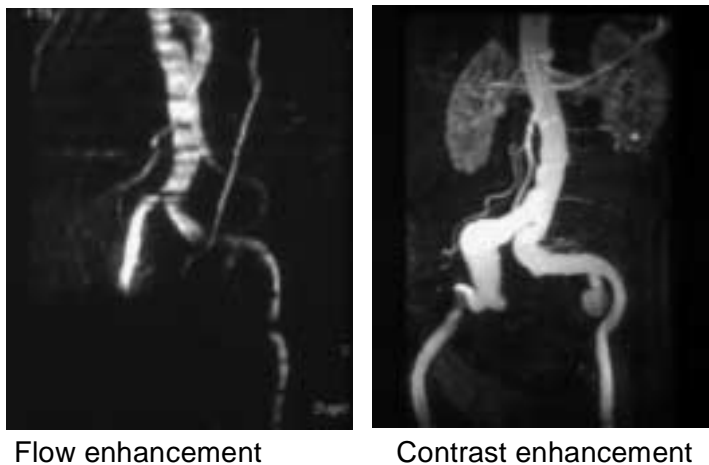
Description of SmartStep

SmartStep (Multi Station) is a feature that provides automatic table movement and switching of prescribed coils between stations, including from body to phased array, and/or between phased array elements. SmartStep is used with 3D Fast Time Of Flight Gradient Echo (TOF GRE)/SPoiled Gradient Echo (TOF SPGR) and 3D Fast GRE/SPGR.

Contrast Mechanism

SmartStep is used to chase a bolus of contrast down the lower extremities. In Contrast-enhanced Magnetic Resonance Angiography (CEMRA), the mechanism used is the T1 shortening effect of gadolinium and not flow enhancement. Gadolinium shortens the T1 of blood from 1200 ms to approximately 100 ms. Consequently, slice locations can be prescribed so that the vessels run in plane and not through plane. In Figure 12-1, images are displayed of both flow and contrast enhancements.

Figure 12-1 Flow vs. Contrast Enhanced Images



SmartStep User CVs

There are several options located on the User CVs Screen. The number of options increase if the SmartPrep imaging option is added to the acquisition. Options include Number of Stations, Image Acquisition Delay, Turbo Mode, SPECIAL, K-space and various Acquisition Types. Figure 12-2 displays the User CVs options available without the SmartPrep feature.

Figure 12-2 Example of the SmartStep User CVs Screen

<i>USER CONTROL VARIABLES</i>			
		Minimum	Maximum
CV 4	Image acq. delay (sec)	0	100
CV 6	Turbo Mode (0=off, 1=Faster, 2=Fastest)	0	2
CV 10	SPECIAL (0=off, 1=on)	0	1
CV 11	Reverse Elliptical Centric (0=off, 1=on)	0	1
CV 12	Elliptical Centric (0=off, 1=on)	0	1
CV 13	Centric (0=off, 1=on)	0	1
CV 14	Reverse Centric (0=off, 1=on)	0	1
CV 17	Mask Acquisition (0=off, 1=on)	0	1
CV 18	Venous Acquisition (0=off, 1=on)	0	1

Meta-series

A Meta-series consists of multiple series linked together. You can link up to four series together at one time. By doing so, the scanner automatically moves the table after each series to the next pre-determined point, as well as switches on and off the appropriate coils, you selected at the time of set-up.

NOTE: The Multi Station imaging option must be selected for the system to automatically create a Meta-series, once the first series is saved. You can then edit the changes you want made to the parameters.

You have the ability to select scan parameters unique for each station, with the exception of Plane, Scan Mode and Pulse Sequence. Figure 12-3 displays an example of a three station Meta-series. Table 12-1 provides the descriptions of areas pointed out in Figure 12-3.

Figure 12-3 Rx Manager of three station Meta-series

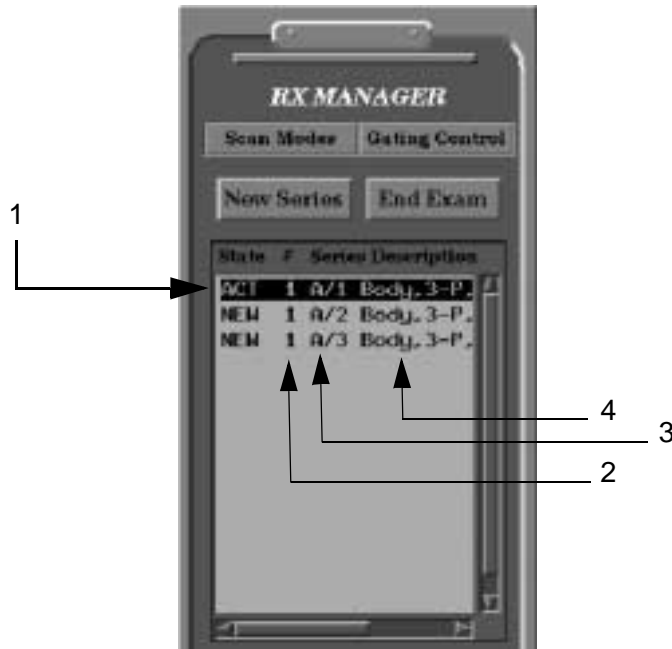


Table 12-1 Descriptions of number pointed out in Figure 12-3

Numbers	Description
1	<p>This area displays the State of the Meta-series.</p> <ul style="list-style-type: none"> • NEW represents the series has just been created; nothing has been done to it yet. • INRX represents that the series is currently in the view/edit mode. • RXD represents that the series has been prescribed. • ACT represents that the series is in an active state and has been downloaded. • PSCD represents that the series has been prescanned. • SCND represents that the series has been scanned.
2	<p>This area displays the series number. Figure 12-3 displays a 1 in this column which signifies the first series for this exam.</p> <p>NOTE: The series number is displayed for each station of the Meta-series.</p>
3	<p>This area represents the acquisition type and the station number.</p> <ul style="list-style-type: none"> • “M” represents Mask Phase • “A” represents Arterial Phase • “V” represents Venous Phase <p>The number after the phase distinction represents the station (Meta-series) number.</p>
4	<p>This area represents the series description. It displays a shortened version of the series description you entered in the Patient Position area. If nothing has been entered for the series description, the system automatically enters one for you. It includes the coil type and the scanning plane. An example of this is shown in Figure 12-3.</p> <p>NOTE: You can change the series description for each station once you are in view/edit mode for that station.</p>

Image Acquisition Delay

Image Acquisition Delay is an option that allows you to enter a scan pause time before the start of your acquisition. The maximum delay time is 100 seconds; it is entered on the **User CVs Screen**. The delay period begins after prescanning and prior to the scanning of the acquisition. The monitor and the magnet enclosure displays and counts down the delay time you entered. After the delay time reaches zero, your system displays the acquisition time and the system begins to scan.

Turbo Mode

Turbo mode is available on HiSpeed Plus, Echospeed™, and TwinSpeed™ systems. It reduces the width of the RF pulse and allows shorter TR periods. With Turbo Mode off, the duration of the RF pulses is approximately 1.6 ms. With Turbo Mode on, the duration of the RF pulses is approximately 0.8 ms and 0.6 ms. Therefore, a reduction in scan times is noticed. This option performs in two modes. If you enter a 1 in the **Turbo Mode** text box, your system performs in fast mode. Enter a 2 in the **Turbo Mode** text box, your system performs in faster mode. If a 0 is entered, the Turbo Mode option is off.

SPECIAL

SPECIAL is Spectral Inversion at Lipids is a fat suppression technique that uses a 180° inversion pulse to nullify the signal from fat. This option is not compatible with Elliptic-centric or Reverse Elliptic-centric K-space filling.

NOTE: Refer to the Imaging Options chapter for additional information on the SPECIAL feature.

K-space Filling

When using SmartStep in conjunction with SmartPrep or the Fluoroscopic Triggered Magnetic Resonance Angiography (FT MRA) imaging option, K-space can be filled in one of four ways. Table 12-2 outlines the four options.

Table 12-2 K-space Filling Options

K-space Filling Options	Fill K-space How...
Reverse Elliptical-centric	Fills outer lines and outer slices first.
Elliptical-centric	Fills the center lines and center slices first.
Centric	Fills the center lines first.

K-space Filling Options	Fill K-space How...
Reverse Centric	Fills the outer lines first.

NOTE: Refer to the Bolus Triggering chapter for additional information on K-space filling.

Acquisition Type

There are three acquisition types that can be used.

- Mask Acquisition
- Arterial Acquisition
- Venous Acquisition

Mask Acquisition scans the prescribed stations prior to administration of contrast. Arterial Acquisition scans all prescribed stations for contrast in the arterial phase. Venous Acquisition scans all prescribed stations for contrast in the venous phase. You can use all three acquisition types within the same exam series. The Acquisition type is displayed in the **Rx Manager**, located on the **Scan Desktop**. Figure 12-3 displays an example of an Arterial Acquisition. Enter a 1 in the **Mask** and/or **Venous** text boxes to turn this feature on. Enter a 0 in the **Mask** and/or **Venous** text boxes to turn this feature off.

NOTE: The mask and venous series will not appear in the **Rx Manager** until after the prescan has been completed for the meta-series. The **Rx Manager** automatically updates and posts all acquisition types you selected from the **User CVs Screen**.

How Do I...

This section provides the step-by-step instructions for bolus chasing utilizing SmartStep. Specifically, it describes how to:

- Scan with SmartStep
 - Patient Preparation
 - Scan the Localizer Series
 - Set Up The Scan Parameters
 - Set Up Of Graphic Parameters
 - Scan the SmartStep Series

NOTE: The five sub-sections must be followed in the order provided above to successfully perform a SmartStep exam.

Scan with SmartStep

Patient Preparation

Use this procedure to perform a scan with SmartStep. With SmartStep, the system automatically advances the table and starts the next prescribed series.

You should already know how to setup a protocol for your system; only a brief review is provided. The rest of the procedure guides you through the SmartStep scanning process.

NOTE: It is suggested that you use SmarPrep or FT MRA, if you have it on your system. This takes the guesswork out of bolus timing.

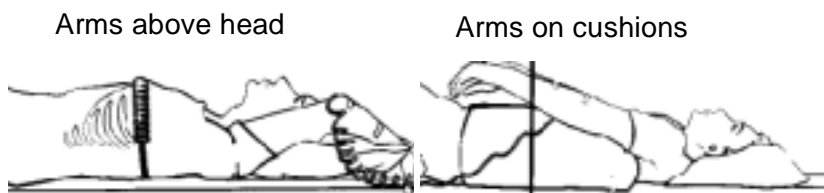
Refer to Working Safely chapter in Volume 1 for important information regarding patient safety.

1. Select the appropriate coil.
 - ◆ Refer to the Gradient, Shim and Imaging Coils chapter in Volume 1 for suggested coil positioning.
 - ◆ It is recommended that you use the Peripheral Vascular (PV) coil for bolus chasing exam, although the body coil can be used for bolus chasing.
2. Position the patient feet first.
 - ◆ This ensures that the patient's head is close to the magnet entrance, making it easier to give breathing instructions.
3. Elevate the patient's legs with sponges.
 - ◆ This step is not needed, if using the peripheral vascular coil.
 - ◆ This places your patient's legs parallel to the table.
4. Place Respiratory Bellows on the patient (optional).
 - ◆ This is helpful in detecting when and how long your patient is suspending respirations during breath holding techniques.
 - ◆ Refer to the Gating and Triggering chapter for correct placement techniques.
5. As directed by physician, set up the patient IV catheter.
 - ◆ Follow your physician's or facility's guidelines.



In Brief: Patient Preparation

1. Select the appropriate coil.
2. Position the patient feet first.
3. Elevate the patient's legs with sponges.
4. Place Respiratory Bellows on the patient (optional).
5. As directed by physician, set up the patient IV catheter.
6. Prepare the power injector (optional).
7. Bring your patient's arms above their head.
8. Landmark your patient by pressing **[Landmark]**.
9. Record off-sets of remaining stations you wish to scan.
10. Press **[Move to Scan]**.

6. Prepare the power injector (optional).
 - ◆ Follow your power injector specifications.
 - ◆ If a power injector is not used, follow your facility's procedure for administering rapid bolus injections.
7. Bring your patient's arms above their head.
 - ◆ This minimizes the chance for a wrap around artifact.
 - ◆ If your patient can not bring their arms up above their head you can elevate them on cushions, to help minimize wrap around artifact.



Display of Patient Arm Position

8. Landmark your patient by pressing **[Landmark]**  .
 - ◆ Landmark for your first station only.
9. Record off-sets of remaining stations you wish to scan.
 - ◆ It is recommended that you use the suggested off-sets.
 - ◆ If the suggested off-sets are not used with the PV coil, images may result in coil cut-off.
 - ◆ use the align light to record the location of any additional off-sets.
10. Press **[Move to Scan]**  .

Scan with SmartStep

Scan the Localizer Series

Use this procedure following the patient preparation portion of the exam. The steps provided give you instructions on how to set up and scan a multi station Meta-series localizer.

1. Click **Pt. Position** icon.
 - ◆ Located on the **Scan Desktop**.
2. Select **Plane > 3 Plane**.
 - ◆ Located in the **Imaging Parameters** area.
3. Select **Mode > 2D**.
 - ◆ Located in the **Imaging Parameters** area.
4. Select **Grad Mode > Whole** (For TWIN systems only).
 - ◆ Refer to the Gradient, Shim and Imaging Coils chapter for additional information on Gradient Mode.
5. Select **Pulse Sequence > Localizer**.
 - ◆ Located in the **Imaging Parameters** area.
6. Enter a series description.
 - ◆ Suggested name `Top Loc.`
7. Select **Imaging Options > NPW** and **Multi Station**.
 - ◆ No Phase Wrap (NPW) prevents aliasing of anatomy inside a prescribed Field of View (FOV).
 - ◆ Use **Multi Station** for acquiring localizers for all stations within one acquisition.
8. Click **[Accept]**.
 - ◆ This registers the imaging options into your current acquisition.
9. Click **User CVs** icon.
 - ◆ Located on the **Scan Desktop**.
10. Enter the **Number of Stations** you want to scan in the text box.
 - ◆ Up to four stations can be entered.

In Brief: Scan the Localizer Series

1. Click **Pt. Position** icon.
2. Select **Plane > 3 Plane**.
3. Select **Mode > 2D**.
4. Select **Grad Mode > Whole** (For TWIN systems only).
5. Select **Pulse Sequence > Localizer**.
6. Enter a series description.
7. Select **Imaging Options > NPW** and **Multi Station**.
8. Click **[Accept]**.
9. Click **User CVs** icon.
10. Enter the **Number of Stations** you want to scan in the text box.
11. Click **[Accept]**.
12. Enter values into the **Center FOV** text boxes.
13. Enter the number of slices into the text box.
14. Enter remaining imaging parameters.
15. Click **[Save Series]**.
16. Double-click on the next station in the Meta-series.
17. Change Series Description.
18. Change coil type (if necessary).

In Brief: Scan the Localizer Series cont.

19. Change Center FOV off-set to ± 420 .
20. Click **[Save Series]**.
21. Repeat steps 16-20 for third and any additional stations. Make series description and off-set changes, as necessary.
22. Click the first station in Meta-series labeled "Top Loc".
23. Click **[Prepare to Scan]**.
24. Click **[Prescan All]**.
25. Give patient breathing instructions.
26. Click **[Scan]**.
27. Click next series in the localizer set.
28. Click **[Scan]**.
29. Repeat steps 27-28 for remaining stations within the Meta-series.

11. Click **[Accept]**.
 - ◆ This registers the number of stations into the current acquisition.
12. Enter values into the **Center FOV** text boxes.
 - ◆ Suggested parameters: 0 S/I, 0 A/P and 0 R/L.
13. Enter the number of slices into the text box.
 - ◆ You can enter only an odd number of slices, for example 1, 3, 5, or 9.
 - ◆ It is recommended you not enter more than three slices. This ensures scan times are kept short for breath holding techniques.
14. Enter remaining imaging parameters.
 - ◆ Choose an FOV to cover desired anatomy. Recommended FOV is 44.
 - ◆ Enter slice thickness and spacing.
15. Click **[Save Series]**.
 - ◆ This closes the view/edit mode and changes series status to RXD.
 - ◆ Deposits Meta-series in the **Rx Manager**.
16. Double-click on the next station in the Meta-series.
 - ◆ Opens the second Meta-series up in view/edit mode.
17. Change Series Description.
 - ◆ You may choose to enter any description. The suggested description is *Mid Loc*.
 - ◆ This allows you to distinguish the localized Meta-series at a glance within the **Rx Manager** area.
18. Change coil type (if necessary).
 - ◆ You must change your coil type if you are using the PV coil.
19. Change Center FOV off-set to ± 420 .
 - ◆ Establishes second station center FOV.
 - ◆ Only use the suggested inferior off-set if your patient is in the PV coil.
 - ◆ If you choose not to use the suggested off-set, when scanning with the body coil, enter desired off-set now.

20. Click **[Save Series]**.
 - ◆ Closes the view/edit mode and changes series status to RXD.
 21. Repeat steps 16-20 for third and any additional stations. Make series description and off-set changes, as necessary.
 - ◆ You may choose to enter any description. The suggested third station series description is Bot Loc.
 - ◆ Suggested off-set for third station is I840.
 22. Click the first station in Meta-series labeled "Top Loc".
 - ◆ Highlights the first Meta-series.
 23. Click **[Prepare to Scan]**.
 24. Click **[Prescan All]**.
 - ◆ This prescans all stations within the Meta-series.
 25. Give patient breathing instructions.
 - ◆ Instruct the patient to suspend breathing until the table starts to move to second station.
 - ◆ If your patient has difficulty suspending their breath, follow your facility's guidelines on breath holding techniques.
 26. Click **[Scan]**.
 - ◆ Located on the **Rx Manager** on the **Scan Desktop**.
 - ◆ Initiates the first Meta-series acquisition.
- NOTE:** Only the highlighted series will be scanned.
27. Click next series in the localizer set.
 - ◆ This highlights this series and prepares it for downloading.
 28. Click **[Scan]**.
 - ◆ Located on the **Rx Manager** on the **Scan Desktop**.
 - ◆ Initiates the next Meta-series acquisition.
 29. Repeat steps 27-28 for remaining stations within the Meta-series.

Scan with SmartStep

Set Up The Scan Parameters

In Brief: Set Up The Scan Parameters

1. Click [**New Series**].
2. Enter **Patient Position** information.
3. Change coil type (if necessary).
4. Enter 3D Top in the **Series Description** text box.
5. Select **Plane > Oblique**.
6. Select **Mode > 3D**.
7. Select **Grad Mode > Whole** (For TWIN systems only).
8. Select **Pulse Sequence > Fast TOF SPGR**.
9. Select **Imaging Options > Multi Station, ZIPx2, ZIP 512 and SmartPrep or Fluoro Trigger**.
10. Enter all remaining imaging parameters.
11. Click [**Contrast**].
12. Enter in the correct amount of contrast being given.
13. Click [**Vascular Screen**].
14. Click **On** for collapsed image.
15. Enter 0 for the number of projections.
16. Click [**User CVs Screen**].

Use this procedure following Patient Preparation and Scan the Localizer Series portions of the exam. The steps provided give you instructions on how to set up the scan parameters of a SmartStep series.

1. Click [**New Series**].
 - ◆ Opens up a new blank scan prescription.
2. Enter **Patient Position** information.
 - ◆ Recommended you use the PV coil, if available.
 - ◆ Patient entry must match entry of localizer series.
3. Change coil type (if necessary).
 - ◆ Recommended you use the PV coil, if available.
4. Enter 3D Top in **Series Description** text box.
 - ◆ Located in the **Patient Position** area.
5. Select **Plane > Oblique**.
 - ◆ Located in the **Imaging Parameters** area.
6. Select **Mode > 3D**.
 - ◆ Located in the **Imaging Parameters** area.
7. Select **Grad Mode > Whole** (For TWIN systems only).
 - ◆ Refer to the Gradient, Shim, and Imaging Coils chapter for additional information on Gradient Mode.
8. Select **Pulse Sequence > Fast TOF SPGR**.
 - ◆ Refer to the Fast Time of Flight Pulse Sequences chapter in Volume 2 for pulse sequence specifications.
9. Select **Imaging Options > Multi Station, ZIPx2, ZIP 512 and SmartPrep or Fluoro Trigger**.
 - ◆ All imaging options listed above can be used, but are not required, with the exception of Multi Station. Multi Station must be selected in order to perform a Bolus Chasing procedure.
 - ◆ Selecting ZIP 1024 may require too much system memory, and is not recommended.

NOTE: SmartPrep and Fluoro Trigger imaging options cannot be used at the same time. You can only select one.

10. Enter all remaining imaging parameters.
 - ♦ Suggested parameters would be: Minimum TE, 45° Flip Angle, 46-48 FOV, 3 slice thickness, 32-40 locations, 256x128 matrix, 0.8 Phase FOV, 1 NEX and turn AutoShim on.
11. Click [**Contrast**].
 - ♦ **Ammt** and **Agent** text box becomes active.
12. Enter in the correct amount of contrast being given.
 - ♦ The correct amount of contrast is needed to establish an accurate threshold for the patient.
13. Click [**Vascular Screen**].
 - ♦ Located in the **Additional Parameters** area.
14. Click **On** for collapsed image.
 - ♦ This allows your system to reconstruct a collapsed image of the scanned areas.
15. Enter 0 for the number of projections.
 - ♦ This saves reconstruction time. Images can be post processed later for projection images.

NOTE: Refer to Interactive Vascular Imaging chapter in Volume 5 for information on creating projection images.

16. Click [**User CVs Screen**].
 - ♦ Located in the **Additional Parameters** area.
17. Enter the **Number of Stations** you want in the text box.
 - ♦ Up to four stations can be entered.
18. Enter the **Max. monitor period** in the text box (if necessary).
 - ♦ This option is only available if the SmartPrep imaging option was selected.
 - ♦ It is recommended you use a 50 second delay. This allows sufficient time for the system to detect the bolus.

In Brief: Set Up The Scan Parameters cont.

17. Enter the **Number of Stations** you want in the text box.
18. Enter the **Max. monitor period** in the text box (if necessary).
19. Enter the **Image acq. delay** in the text box.
20. Turn on K-space filling option.
21. Turn on Mask and/or Venous acquisition options (optional).
22. Turn on or off any other desired options, on the **User CVs Screen**.
23. Click [**Accept**].

19. Enter the **Image acq. delay** in the text box.
 - ◆ This text box value should reflect adequate time to give patient breathing instructions.
 - ◆ A 5 - 8 second delay is recommended.
20. Turn on K-space filling option.
 - ◆ You can only turn on one K-space filling option
 - ◆ Refer to the K-space section of this chapter for additional information on the K-space filling options.
21. Turn on Mask and/or Venous acquisition options (optional).
 - ◆ Refer to the Acquisition Type section of this chapter for additional information on Mask and Venous acquisitions.

NOTE: SmartPrep or Fluoro Trigger imaging options are only present in the first station of the Arterial Acquisition Meta-series.

It is recommended that a Mask Acquisition is acquired whenever performing this type of scan. This ensures correct volume placement and helps to improve image quality when subtraction post processing techniques are used.

22. Turn on or off any other desired options, on the **User CVs Screen**.
 - ◆ FAT SAT must be selected prior to choosing SPECIAL on the screen.

NOTE: SPECIAL can not be used with elliptic centric K-space filling.

23. Click [**Accept**].
 - ◆ This registers the User CVs into the current acquisition.

Scan with SmartStep

Set Up Of Graphic Parameters

Use this procedure following Patient Preparation, Scan the Localizer Series and Set Up of Scan Parameters portions of the exam. The steps provided give you instructions on how to set up the graphic parameters of a SmartStep series.

1. Click **[Graphic Rx]**.
 - ◆ Located in the **Additional Parameters** area.
 2. Click **[Select Series]**.
 3. Select your “Top Loc” series.
 - ◆ This is your first station of the localizer Meta-series.
 4. Click once on the image to deposit your 3D imaging volume.
 - ◆ It is recommended you choose a mid-sagittal slice to place imaging volume on.
 - ◆ Adjust angle to insure proper coverage of anatomy.
- NOTE:** Be careful to keep the center FOV “tick” mark at I/S 0 mm which is represented by the horizontal reference line.
5. Click **[Tracker]** (if necessary).
 - ◆ This option is only available if you have selected the SmartPrep imaging option.
 - ◆ Refer to Bolus Triggering chapter for information on how to place a tracker.
 6. Click **[Accept]**.
 - ◆ This registers the graphic options into your current acquisition.
 7. Click **[Save Series]**.
 - ◆ This registers the graphic options into your current acquisition.
 - ◆ Deposits Meta-series in the **Rx Manager**.
 8. Double-click the next station in the Meta-series.
 - ◆ Opens second series into view/edit mode.

In Brief: Set Up Of Graphic Parameters

1. Click **[Graphic Rx]**.
2. Click **[Select Series]**.
3. Select your “Top Loc” series.
4. Click once on the image to deposit your 3D imaging volume.
5. Click **[Tracker]** (if necessary).
6. Click **[Accept]**.
7. Click **[Save Series]**.
8. Double-click the next station in the Meta-series.
9. Change the **Series Description** to 3D Mid.
10. Change coil type (if necessary).
11. Change your K-space filling option, on the **User CVs Screen**.
12. Click **[Graphic Rx]**.
13. Click **[Select Series]**.
14. Select your “Mid Loc” series.
15. Click once on the image to deposit your 3D imaging volume.
16. Click **[Accept]**.
17. Click **[Save Series]**.
18. Repeat steps 8-17 for all remaining stations.

9. Change the **Series Description** to 3D Mid.
 - ◆ You may choose to enter any description. The suggested description is 3D Mid.
 - ◆ This allows you to distinguish the localized Meta-series at a glance within the **Rx Manager**.
10. Change coil type (if necessary).
 - ◆ You must change coil type if you are using the PV coil.
11. Change your K-space filling option, on the **User CVs Screen**.
 - ◆ It is recommended that you change your filling option for each station. By doing so you improve your probability of catching the bolus at each station.
 - Top station = Centric filling.
 - Middle Station = Centric filling.
 - Bottom and any remaining Stations = Elliptical Centric filling.
12. Click [**Graphic Rx**].
 - ◆ Located in the **Additional Parameters** area.
13. Click [**Select Series**].
14. Select your “Mid Loc” series.
 - ◆ This is the second station of the localizer Meta-series.
15. Click on the image to deposit your 3D imaging volume.
 - ◆ It is recommended you choose a mid-sagittal slice to place imaging volume on.
 - ◆ Adjust angle to insure proper coverage of anatomy.
16. Click [**Accept**].
 - ◆ This registers the graphic options into your current acquisition.
17. Click [**Save Series**].
 - ◆ This registers the graphic options into your current acquisition.
18. Repeat steps 8-17 for all remaining stations.
 - ◆ Change third station Series Description to 3D Bot.

Scan with SmartStep

Scan the SmartStep Series

Use this procedure following Patient Preparation, Scan the Localizer Series, Set Up of Scan Parameters and Set Up of Graphic Parameters portions of the exam. The steps provided give you instructions on how to scan the SmartStep series.

1. Click 3D Top series.
 - ◆ Located in the **Rx Manager** area.

NOTE: If you have chosen to perform a Mask acquisition make sure you click on the series labeled with an "M." An example of what may appear in the Rx Manager is:

RXD 1 M/1 3D Top

2. Click **[Prepare to Scan]**.
 3. Click **[Prescan All]**.
 - ◆ This prescans all stations within the Meta-series.
 - ◆ All series prescanned displays PSCD in the status area of the **Rx Manager**.
 4. Clear message log window (if necessary).
 - ◆ This allows you to see you to see SmartPrep system prompts, if the SmartPrep imaging option has been selected.
- NOTE:** Refer to the Bolus Triggering chapter for additional information on SmartPrep system prompts.
5. Skip to step eight if **NOT** performing a Mask series. Click on first station of Mask Meta-series.
 - ◆ If you prescribed a mask Meta-series, the cursor should highlight PSCD M/1.
 - The system will stop scanning when all mask stations have been scanned. This allows time to prepare for contrast injection.

NOTE: You can highlight any series you want to start scanning from. For example, if the patient is claustrophobic and you decide to skip the mask series, place the cursor on the first station of the arterial series.

In Brief: Scan the SmartStep Series

1. Click 3D Top series.
2. Click **[Prepare to Scan]**.
3. Click **[Prescan All]**.
4. Clear message log window (if necessary).
5. Skip to step eight if **NOT** performing a Mask series. Click on first station of Mask Meta-series.
6. Click **[Prepare to Scan]**.
7. Click **[AutoStep]**.
8. Click the first station of the Arterial Meta-series.
9. Click **[Prepare to Scan]**.
10. Click **[AutoStep]**.
11. Skip this step and the next step if you are using SmartPrep. Make adjustments to the fluoro triggered image to ensure a mid-line slice of the vessel.
12. If using Fluoro Trigger, click **[Go3D]**, once bolus fills the vessel.
13. Click **[AutoStep]** again when all scanning is complete.

6. Click **[Prepare to Scan]**.
 - ◆ This downloads the acquisition and moves the table to its starting position.
 - ◆ This allows you to be able to give breathing instructions, if Mask acquisition was selected.
7. Click **[AutoStep]**.
 - ◆ Located on the **Rx Manager** on the **Scan Desktop**.
 - ◆ Initiates the first highlighted Meta-series acquisition. All stations within the Mask Meta-series are scanned.

NOTE: The system will stop after Mask Meta-series is acquired. This allows you to prepare for contrast injection.

8. Click the first station of the Arterial Meta-series.
 - ◆ This highlights this series and prepares it for downloading.
 - ◆ If no mask Meta-series was prescribed, the cursor should highlight PSCD A/1.
9. Click **[Prepare to Scan]**.
 - ◆ This downloads the acquisition and moves the table to its starting position.
10. Click **[AutoStep]**.
 - ◆ Located on the **Rx Manager** on the **Scan Desktop**.
 - ◆ Initiates the first highlighted Meta-series acquisition.
 - ◆ If Fluoro Trigger is used the system will switch to the Fluoro Trigger mode.
11. Skip this step and the next step if you are using SmartPrep. Make adjustments to the fluoro triggered image to ensure a mid-line slice of the vessel.
 - ◆ Refer to the Real Time Imaging chapter in this volume for additional information on options seen on the FT MRA mode screen.
12. If using Fluoro Trigger, click **[Go3D]**, once bolus fills the vessel.
 - ◆ This step is only necessary if you have selected the Fluoro Trigger imaging option.
 - ◆ This triggers the scan mode of the Arterial Acquisition. All series within the Meta-series will be scanned.

NOTE: Refer to the Bolus Triggering chapter for additional information on Fluoro Trigger.

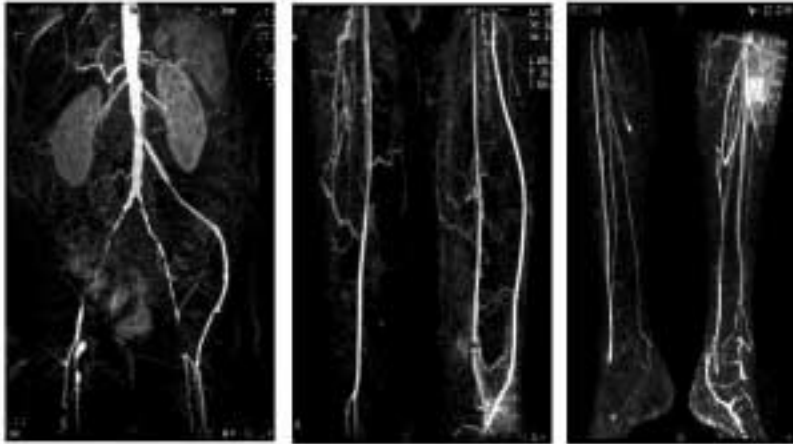
13. Click **[AutoStep]** again when all scanning is complete.

- ◆ This turns the automatic scan feature off. Ensures no accidental scanning of next prescribed series until you are ready.

3D Top Series

3D Mid Series

3D Bot Series



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Chapter 13

Imaging Real Time

Introduction

iDrive[™] Pro Plus is an optional software package that provides a flexible environment for imaging Real Time Cardiac Acquisitions (RTCAs). *iDrive* Pro Plus can be used to interactively manipulate the scan plane and image contrast. Images you acquire with *iDrive* Pro Plus can be used to prescribe scan planes and locations for other series in the exam once the correct plane and locations have been determined.

This chapter explains how to image real time with *iDrive* Pro Plus. It provides key concepts regarding the acquisition, tools, image review options, and application tips on where to use interactive imaging. This chapter also contains the step-by-step instructions to help you learn how to:

- Prescribe a real time sequence
- Use the Movement tools
 - Drive through an image volume
 - Step through an image volume
- Manage Home Images
 - Define a scan plane
 - Define new Home Images
- Manage Bookmarks
 - Create a Bookmark
 - Recall a Bookmark
 - Enlarge a thumbnail and apply for scanning

- Use the Graphic tools
 - Change the FOV center
 - Draw a line in the Main Viewer
 - Draw a line in the Scout Viewer
 - Draw a line in the Multi-slice Mode
 - Apply the 2 Point tool
 - Apply the 3 Point tool
- Review real time images
 - Playback images
 - Save images

In addition, this chapter answers the following questions:

1. What pulse sequences can I use with *i*Drive Pro Plus?
2. What factors affect frame rate?
3. What tools are available on the *i*Drive Pro Plus Acquire tab?
4. What are Home Images?
5. What are Bookmarks?
6. What tools are available on the *i*Drive Pro Plus Review tab?
7. What are the applications for imaging with *i*Drive Pro Plus?

What Do I Need to Know About...

This section presents the concepts necessary to successfully complete imaging real time process with iDrive Pro Plus. Specifically, you need to understand:

- Real Time Imaging Overview
- Real Time Imaging Basics
 - Frame Rate
 - Image Acquisition
- Acquire Tab
 - Home Images
 - Bookmarks
 - Image Buffer
 - Multi-slice Mode
- Acquire Tab Tools
 - Movement Tools
 - Orientation Tools
 - Contrast Tools
 - Graphic Tools
 - Parameter Tools
 - Graphic Prescription Tools
- Review Tab
 - Review Images
 - Image Slider
- Applications
- Troubleshooting Tips

Real Time Imaging Overview

Real time imaging allows you to navigate through your patient's anatomy for rapid visualization and monitoring of temporal physiological events. This includes, but is not limited to, patient breathing, kinematic studies, and bolus activity. Real time images can also be used for directly prescribing scan planes of other series in the exam. The Real Time Imaging Option allows for Real Time Cardiac Acquisitions (RTCAs) with the *i*Drive Pro Plus optional software package.

Real Time Imaging Basics

*i*Drive Pro Plus is an optional software package that allows you to image RTCAs with greater flexibility. You can use *i*Drive Pro Plus to interactively manipulate the scan plane and image contrast. Images you acquire with *i*Drive Pro Plus can be used to prescribe scan planes and locations for other series in the exam once the correct plane and locations have been determined.

RTCAs can be acquired with the following pulse sequences:

- Fast Gradient Echo (FGRE)
- Fast Spoiled Gradient Echo (FSPGR)
- Fast Gradient Echo-Echo Train (FGRET)
- Spiral GRE
- Spiral SPGR

Frame Rate

The Advisory panel of the Scan Rx desktop displays the number of images acquired in one second based on the current series parameters. This is shown in the frames per second (FPS) status area. The gradient platform and array processor configuration affect the maximum number of images or frames per second that can be generated. Another factor affecting the frame rate is the number of receive coils. The use of a phased array coil may decrease the frame rate as compared to a single receive coil.

When imaging with *i*Drive Pro Plus, the phase and frequency matrix selections are the predominant factors affecting the FPS in non-Spiral acquisitions. In Spiral scans, the number of arms and number of points are the predominant factors affecting the FPS.

Image Acquisition

To use the features of the Real Time Imaging Option, you must first prescribe a single-slice series at the Scan Rx desktop. This series must have Real Time selected at the Imaging Options window. The real time series can be saved as a stand-alone protocol or as part of a larger protocol with an existing batch series. It can be cut, copied or pasted using the Rx Manager tools and can be used in a protocol that is being automatically scanned.

When you start the scan, there is a slight pause (less than six seconds) before the system is ready to display the images. The tools and functions available on the Acquire tab help you manipulate the scan plane and contrast of the images. These actions are a combination of button selections and cursor manipulations on the image screen itself.

When the real time application is launched, Archive, Network, and Filming operations are automatically paused by the system. However, there is **no** notification of the pause status. These processes automatically resume when the real time application is closed.

Images acquired real time are not automatically saved to the system disk. The **[Save Image]** button on the Acquire tab saves a single image to the disk when that image is displayed in the Acquire tab Main Viewer.

Data acquisition can be paused by clicking the **[Pause Scanning]** button on the Acquire tab or by pressing the **Pause Scan** hard key on the keyboard. If the keyboard is used to pause scanning, the Acquire tab **[Pause Scanning]** button appears depressed. Scanning can be initiated again with the **Start Scan** hard key or by selecting the **[Pause Scanning]** button on the Acquire tab. When scanning is paused, most of the Acquire tab controls become unavailable.

Acquire Tab

The RTCA Acquire tab (Figure 13-1) displays when the **[Scan]** button is selected from the Scan Rx desktop in a real time prescription with iDrive Pro Plus. Data acquisition begins and three Home Images are acquired, one image in each orthogonal plane.

Figure 13-1 RTCA Acquire Tab

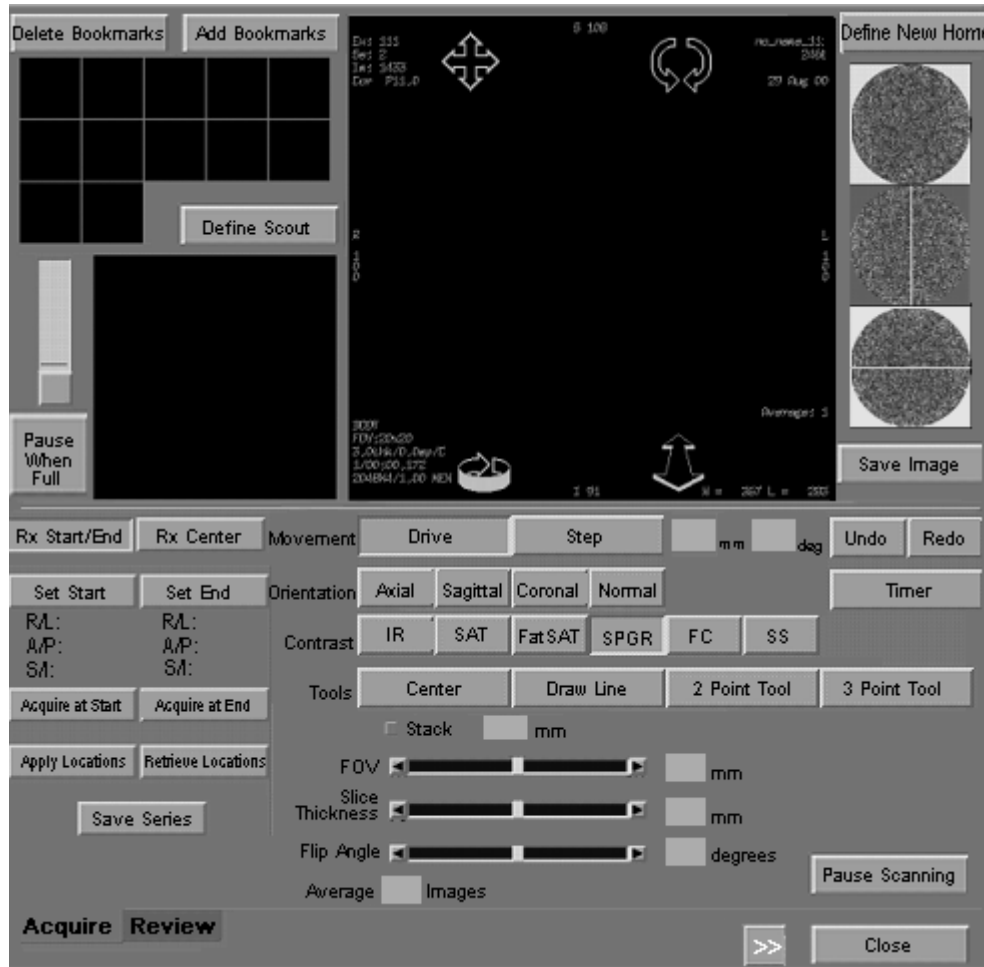



Table 13-1 provides a description and acceptable values for each selection on the Acquire tab for RTCAs imaging with *i*Drive Pro Plus.

Table 13-1 RTCA Acquire Tab Selections and Descriptions

Selection	Description
[Delete Bookmarks]	Deletes all bookmark thumbnails currently displayed. Individual bookmarks cannot be deleted.
[Add Bookmarks]	Saves the plane, location, and image contrast of the current image as a bookmark thumbnail for later recall. Up to 12 images can be bookmarked.
[Define Scout]	Copies the image in the Main Viewer to the Scout Viewer (the viewer directly under the [Define Scout] button).

Selection	Description
Scout Viewer	Contains a static 256x256 image that can be used with the Draw Line tool to prescribe orthogonal real time image planes. This viewer is empty when real time scanning begins.
[Pause When Full]	Pauses the real time data acquisition automatically when the real time image buffer is full. The progress bar provides a graphic display of the image buffer capacity.
Main Viewer	Displays the real time images as real time data acquisition is taking place. This image is also used with the Movement and Graphic Tools for defining new scan planes.
[GO]	Becomes visible on the real time image when the Draw Line tool is selected. It is used to initiate the scan plane change when a line is drawn on the real time image. Alternatively, right-click anywhere on the image to initiate data acquisition.
[Define New Home]	Acquires new home images. The new home images are acquired in three orthogonal planes based on the real time image currently displayed in the Main Viewer.
[Save Image]	Saves the current real time image to the system disk and lists the image in the Browser. Saved images can be used in Graphic Rx in subsequent series.
[Rx Start/End]	Displays the IGRx location tools. The IGRx tools are used to save or retrieve locations for defining additional real time and/or non-real time sequences.
[Rx Center]	Displays the IGRx center tools. The IGRx tools are used to save or retrieve locations for defining additional real time and/or non-real time sequences.
[Undo]	Returns the real time image to the state prior to the most recent change, undoing the most recent scan plane or image contrast change. It can also be used if iDrive Pro Plus has been exited. Selecting the [Undo] button upon re-entering iDrive Pro Plus, the last location scanned in the prior real time session will be acquired provided the ID, Landmark and Patient Position have not changed. In Drive mode, it undoes all Drive functions returning the image to its original state before any Drive tools were applied. In the Step mode, it undoes all Step functions returning the image to its original state before any Step tools were applied.
[Redo]	Cancels the most recent Undo operation. The real time image returns to its previous state.

Selection	Description
[Timer]	Turns the on-image time display on or off. The on-image timer shows the scan time for a single image. When Timer is on, the scan timer on the PC is set to zero. The timer readout updates with each new image acquired and displayed. It displays the time the image was acquired since the [Timer] button was clicked.
Movement	Contains tools used to define the on-image scan plane manipulation features.
Orientation	The scan plane can be quickly returned to any orthogonal orientation, at the current FOV center, by selecting the [Axial] , [Sagittal] , or [Coronal] buttons. The [Normal] button adjusts the image to a normal anatomic presentation. The image is presented such that RAS coordinates are in their "normal" positions in the viewer.
Contrast	Contains tools used to adjust image contrast parameters. The contrast tools available are based on the pulse sequence.
Tools	Provides access to the Graphic tools that provide alternate methods used for manipulating the scan plane.
Stack	Enables the Multi-slice mode. The stack values are shown in millimeters in the range of 10 to 100.
FOV	Allows changes in the prescribed FOV by moving the slider or by entering a value in the text box.
Slice Thickness	Allows changes in the prescribed slice thickness by moving the slider or by entering a value in the text box.
Flip Angle	Allows changes in the prescribed flip angle by moving the slider or by entering a value in the text box.
Average	Specifies the number of images to be averaged to create the real time image. This improves the signal-to-noise ratio (SNR), as well as motion averaging. Averaging occurs as long as the real time image location and contrast setting are not changed. A value of 1 effectively means no averaging. The maximum allowable value is 8.
[Swap Phase/Freq]	Toggles on to swap the phase and frequency matrix directions based on the original series prescription. This is not available for Real Time Spiral Imaging.
[Pause Scanning]	Stops real time data acquisition. The Acquire tab remains open. Selecting the [Pause Scanning] button again resumes data acquisition.

Selection	Description
[Review]	Pauses scanning and moves the display to the iDrive Pro Plus Review tab. The Review tab is used to view and save recently acquired real time images.
Message Area 	Displays all error and warning messages that have been posted throughout the current real time session. Messages displayed are cleared when any action is performed within the user interface. Selecting the double arrows displays a dialog box with a scrollable list of messages that have been displayed for the current real time session.
[Close]	Exits the Acquire tab, stops the current real time session, and returns to the Scan Rx desktop. Once you close iDrive, you cannot access images that have not been saved.

Home Images

The three orthogonal images acquired upon initialization of a real time series are displayed in the three vertical viewers along the right side of the Acquire tab Main Viewer (Figure 13-2). These images are called Home Images. The Home Images created are axial, sagittal, and coronal, based on the locations prescribed at the Scan Rx desktop during the real time series prescription. The Home Images are automatically saved to the system disk.

Figure 13-2 Home Images



During the real time session, cut-lines display on the Home Images indicating where the current real time image intersects the Home Images. As the scan plane is manipulated, the cut-lines update to indicate the new scan plane.

Defining a Scan Plane Based on Home Images

The Home Images are essentially a three-plane localizer. They can be used to define an orthogonal scan plane and new Home Images can be defined. You can also use your Home Images to reset your current scan plane. Clicking on any one of the Home Images obtains a real time image in that scan plane.

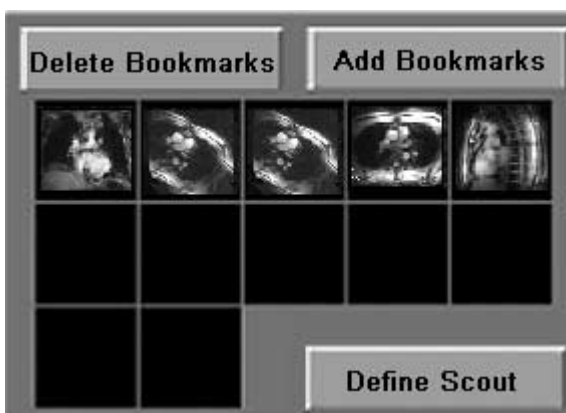
Defining New Home Images

You also have the ability to replace your home images with new images. When you decide that new Home Images are desired at the location of the current real time image, select the **[Define New Home]** button. The first time you define new home images during an acquisition, a message displays informing you that your current home image locations will be replaced by new home images. If this is your intent, click the **[OK]** button. The system then acquires and displays three orthogonal images based on the location of the real time image. This includes the right, anterior, and superior (RAS) offsets of current real time image.

Bookmarks

An image can be bookmarked to recall at a later time. A recall can be performed to obtain the scan plane and image contrast from that image. When an image is bookmarked, it is displayed as a thumbnail image in the Bookmark Viewers (Figure 13-3).

Figure 13-3 RTCA Bookmark Viewers



RTCAs can store up to 12 Bookmarks. A single thumbnail image can be enlarged from a 64x64 to a 128x128 pixel display by leaving the cursor on the image for longer than one second. When you move your cursor off of the enlarged thumbnail image, it immediately returns to its original size. An enlarged thumbnail can be selected for scan by clicking it. This updates the image in the Main Viewer to the contrast and slice view of the Bookmark.

Bookmarks are not automatically saved to the image disk. If a RTCA is exited and re-entered, the Bookmark thumbnails from the prior real time session are saved only if the Patient ID, Landmark, and Patient Position have not changed.

If all thumbnail viewers are filled and the **[Add Bookmarks]** button is clicked, a message posts telling you to right-click on an occupied viewer to replace that thumbnail with the current image. All thumbnail images in RTCAs can be deleted by clicking the **[Delete Bookmarks]** button.

Image Buffer

The Image Buffer holds all of the images acquired with real time. If the buffer is filled and scanning continues, the first images placed into the buffer are deleted to make room for the current real time images using the First In, First Out (FIFO) method. FIFO buffer images are not automatically saved. You can review images in the image buffer and save individual images or an entire range of images. You can also select an image from the buffer and resume scanning at that location. The system automatically pauses scanning once the image buffer fills. Think of the image buffer as fluoroscopy. Nothing is saved unless you “spot film.”

RTCAs imaged with *i*Drive Pro Plus can hold up to 960 real time images. The actual number of images in the buffer depends on the image size of the reconstructed image. For example, an FGRE sequence may allow only 250 images, while Spiral may allow up to 960. These images are held in the real time Image Buffer and the buffer capacity is indicated by the progress bar (Figure 13-4).

Figure 13-4 RTCA Image Buffer Progress Bar



The **[Pause When Full]** button can be toggled on to halt real time data acquisition when the buffer becomes full. This indicates that no images acquired from this point forward are to be discarded. When the number of images acquired equals the capacity of the image buffer, scanning is paused. The progress bar (Figure 13-4) provides a graphic display of the Image Buffer capacity. To clear the buffer, click the **[Pause When Full]** button. The progress bar indicator clears, indicating that the buffer has been reset. When the **[Pause When Full]** button is toggled off, the progress bar is inactive.

When the real time Image Buffer becomes 85% full or greater, the **[Define New Home]** button becomes non-functional when the **[Pause When Full]** button is enabled. If you request new home images to be defined while the buffer is nearing 85% full, the system may not collect the new home images as you requested. In this case, you must empty the Image Buffer before you are able to define new home images.

The arrow button below the Image Buffer progress bar can be used to purge the buffer at any time. Alternatively, the images can be reviewed, saved, and purged from the Review tab.

Note that if the RTCA is closed, the images in the Image Buffer are held in the buffer until a change has been made to the Patient ID, Patient Position, or Landmark. Therefore, if the RTCA is re-entered for the current patient, the real time images from the prior session remain in the Image Buffer.

Multi-slice Mode

Multi-slice mode can be used with *iDrive Pro Plus* to visualize a multiple-slice, or "stack" acquisition during RTCAs. This may be useful to visualize the start and end locations before applying the locations to a series in the Rx Manager. The Stack check box and the **mm** text box (Figure 13-5) are used in conjunction with the Draw Line tool to use Multi-slice mode.

Figure 13-5 RTCA Multi-slice Mode Enable Area



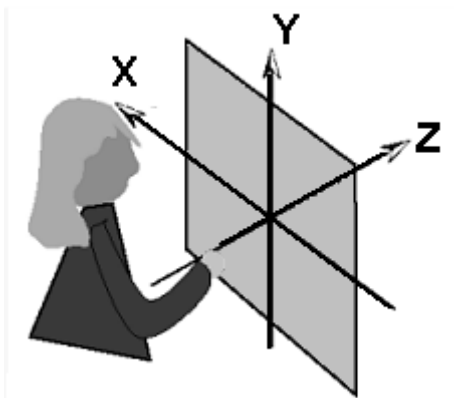
The stack is NOT used to acquire a volume (stack) in *iDrive Pro Plus*; it only designates the stack thickness to use for the Draw Line tool. The range of thickness is 0 to 480 mm. When you change the stack thickness value, the locations are updated on the real time image in the Main Viewport to reflect the new stack thickness entry.

Acquire Tab Tools

The Acquire tab contains tools for you to change the sequence parameters, move the acquisition, change the graphic location, enhance real time image contrast, as well as set up and enable a graphic prescription.

Figure 13-6 displays the orientation of the real time scan plane of the RTCA relative to you and the conventional axis used to describe the real time control tools.

Figure 13-6 Conventional Axis Used to Describe Tools

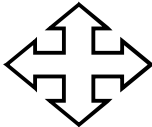



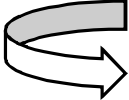
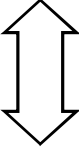
Movement Tools

The scan plane can be manipulated using the Movement tools accessed in both the Drive and Step modes for RTCAs. Each Movement tool is activated by an on-screen (on-image) icon on the real time Main Viewer. These Movement tools enable you to navigate the location of the real time image.

The tool icons are used to access the Movement tools in RTCAs imaged with *iDrive Pro Plus*. When the cursor is moved into one of the four corners of the Main Viewer, the cursor displays the icon associated with that tool accessed in that corner. Table 13-2 illustrates the Movement tools for RTCAs imaged with *iDrive Pro Plus* and provides a description of each.

Table 13-2 RTCA Movement Tools Selections and Descriptions

Movement Tool	Description
Pan 	The Pan cursor is activated by clicking in the upper-left corner. Panning is used to scroll the image in the X and Y directions in the viewer; left and right (X), up and down (Y). The FOV center is changed with no changes to the scan plane obliquity or orientation. When in Step mode, movement occurs in increments based on the value set in the Movement tools text box. This value is displayed in millimeters.

Movement Tool	Description
<p>Rotate</p> 	<p>The Rotate cursor is activated by clicking in the upper-right corner. Rotate turns the image in a clockwise or counter-clockwise motion. The FOV center in the X and Y directions does not change. When in Step Mode, movement occurs in increments based on the value set in the Movement tools text box. This value is displayed in degrees.</p>
<p>Tilt</p> 	<p>The Tilt cursor is activated by clicking in the lower-left corner. Tilt rolls (obliques) the image in the direction of the arrow on the cursor. Movement occurs along the X-axis, the Y-axis or both. When in Step Mode, movement occurs based on the value set in the deg text box.</p>
<p>Translate</p> 	<p>The Translate cursor is activated by clicking in the lower-right corner. The image is rolled (obliques) along the Z-axis, tilting toward or away from you with no change in the angle of the image. No movement occurs in the X or Y directions. When in Step Mode, movement occurs based on the value set in the mm text box. As movement begins, the arrow changes to display the direction of the translation.</p>

The same Movement tools are available for both the Drive and Step modes. The mode simply determines the manner in which the scan plane changes are applied.

Drive Mode

The scan plane is navigated in Drive mode by clicking and dragging the mouse in the Main Viewer. The cursor indicates the direction of movement as the cursor is moved. As you drag the mouse, the extent of movement is annotated in the lower right corner of the real time image. The scan plane updates when you release the mouse button.

In Drive mode, the direction of mouse movement affects the direction of the cursor movement. The cursor icon changes to indicating the direction of movement.

NOTE: The Movement tool text boxes indicating the millimeter and degree of movement are not available in Drive mode. They can only be changed in Step mode.

Step Mode

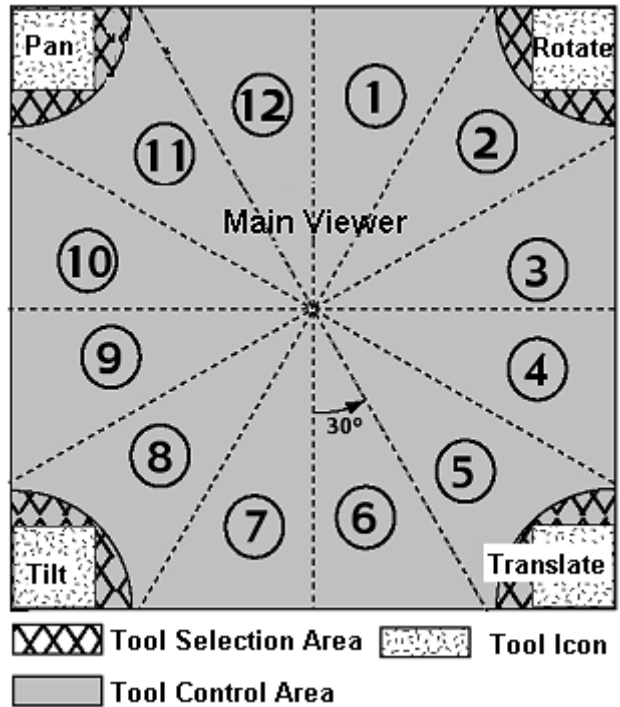
The scan plane is navigated by clicking the left mouse button. As the mouse button is released, the scan plane changes as determined by the increments set in the Movement tools millimeter and degree text boxes. The location of the cursor on the image determines the direction of movement when that tool is used at that point on the image.

When the Step mode is active, you can click and hold and an on-image counter displays. The display indicates the millimeter or degree of the scan plane change that takes place as long as the mouse button is held down. The counter display increases until the mouse button is released. When the mouse button is released, the value on the counter is the change applied to the real time image. The scan plane change depends on the active Movement tool when the mouse button was depressed.

In Step mode, the cursor indicates the direction of movement, but movement direction changes depending on the location of the cursor in the Main Viewer.

The Pan and Tilt tools divide the Main Viewer into 12 zones (Figure 13-7), numbered clockwise from 1 to 12. Each area corresponds to a different movement direction, depending on which tool is selected. Placing the cursor in the viewer and clicking shows location of the cursor at the time the mouse button was clicked. It also determines the movement for that zone and the cursor reflects the direction of that movement.

Figure 13-7 Control Zones and Location of Scan Controls



The Rotate tool divides the Main Viewer vertically into two zones. The cursor indicates the direction of movement. Clicking the cursor in the right half of the viewer results in clockwise movement. Clicking in the left half of the viewer results in counter-clockwise movement.

Translate divides the Main viewer horizontally into two zones. The cursor indicates the direction of movement. Clicking the cursor in the upper half of the viewer results in movement away from you. Clicking in the lower half of the viewer results in movement toward you.

NOTE: When in Step mode, using the right mouse button to initiate the on-image tools results in the opposite effect of using the left mouse button.

Orientation Tools

The orientation tools (Figure 13-8) quickly move the real time image to the specified orthogonal orientation.

Figure 13-8 Orientation Tools



For example, when the **[Axial]** button is clicked, the real time imaging plane moves to the axial plane at the current image center point. The **[Normal]** button moves the real time image to a normal viewing orientation at the current image center point. The image is presented such that RAS coordinates are in their "normal" positions in the viewer.

Contrast Tools

The Contrast tools (Figure 13-9) allow you to interactively make tissue contrast changes to the real time image. These tools apply tissue-specific techniques and are selected by either a push button or a toggle button. The Contrast tools available are based on the pulse sequence.

Figure 13-9 Contrast Tools



Table 13-3 lists the Contrast tools and provides a description of each.

Table 13-3 Contrast Tools

Contrast Tool	Description
[IR]	Available with FGRE. The IR single-shot inversion recovery pulse is applied once with the push button and an image is acquired with the IR pulse. The image then returns to its pre-IR pulse contrast.
[SAT]	Available with FGRE. Applies spatial saturation (SAT) slabs in the slice-select direction. The slabs are automatically concatenated and track the real time image plane. SAT is a toggle button and remains on until it is turned off.
[FatSAT]	Available with FGRE. Fat suppression can be used to null the signal from fat. FatSAT is a toggle button and remains on until it is turned off.
[SPGR]	Available with FGRE and Spiral sequences. A Gradient Echo sequence can be changed to a Spoiled Gradient Echo (RF spoiling) sequence. SPGR is a toggle button and remains on until it is turned off.
[FC]	Available with FGRE. Flow Compensation (FC) is used for gradient moment nulling to decrease flow artifacts. FC is a toggle button that remains on until it is turned off.
[SS]	Spectral Spatial (SS) is not currently available for any pulse sequence.

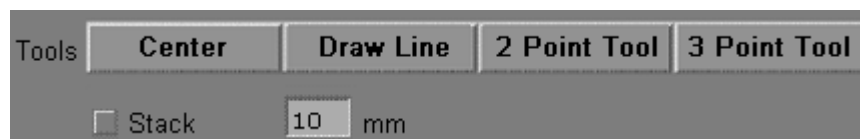
There are several factors you should consider when using the Contrast tools:

- In FGRE sequences with Real Time, FC and SAT selections (Fat Suppression and Spatial SAT) can be made from the SAT screen during series prescription. The corresponding button is depressed when the Acquire tab opens. These options can be turned on and off at the Acquire tab during real time data acquisition.
- SAT is applied in the slice select direction, and when SAT is turned on at the SAT screen, only SAT pulses in the slice-select direction are allowed.
- The Contrast tools are NOT available for FGRET Real Time (FGRET-RT) sequences. However, FC and Fat SAT can be selected during series prescription. They cannot be turned off at the Acquire tab.
- Only SPGR is available for Real Time Spiral sequences. Spectral Spatial RF (SSRF) or Fat SAT can be used with Real Time Spiral, but they must be selected during series prescription and they cannot be turned off or on at the Acquire tab.

Graphic Tools

The Graphic tools provide a means by which you can define a new real time image location by graphically prescribing cut planes through the imaging volume. The Graphic tools available are: Center, Draw Line, 2 Point Tool, and 3 Point Tool (Figure 13-10).

Figure 13-10 Graphic Tools



Center

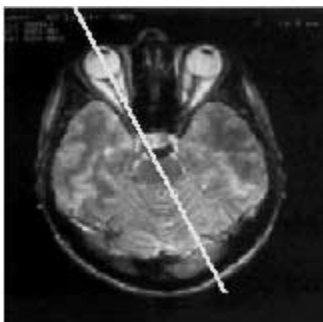
Center changes the FOV center of the real time image to the location of a cursor placed on the real time image. This can be accomplished by selecting the **[Center]** button, placing the cursor on the new FOV center, and clicking the left mouse button to deposit the cursor. The real time image updates to reflect a FOV center at the point of the cursor. Once the new FOV center is defined, the Center tool turns off automatically.

Draw Line

Draw Line is used to define a new acquisition plane by drawing a line on the current real time image in the Main Viewer or on the scout image. Draw Line can also be used to define a stack in Multi-slice mode.

If no scout image has been defined, clicking the **[Draw Line]** button automatically deposits a line on the real time image in the Main Viewer. If a scout image has been defined, the cursor must be placed on either the scout or real time image, followed by a left click on the mouse. The line is deposited at the center of the image. Figure 13-11 illustrates a line defining the scan plane that runs along the optic nerve. The image plane becomes the plane defined by the line.

Figure 13-11 Draw Line Defining a Scan Plane

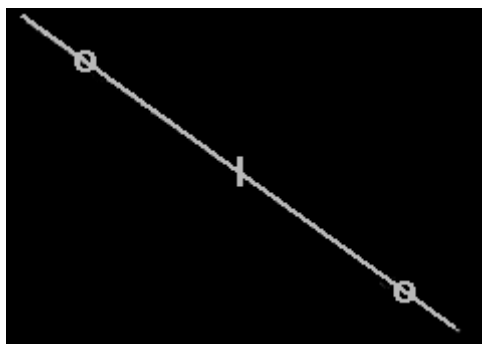


There are three applications for the Draw Line tool.

- Draw Line for the real time image Main Viewer
- Draw Line for the Scout Viewer
- Draw Line for Multi-slice Mode

Draw Line for the real time image Main Viewer draws a line onto the real time image to implement a change to the real time scan plane and acquires an image at the plane of that line. The line (Figure 13-12) deposited on the image is not an indicator of the selected FOV.

Figure 13-12 Real Time Image Main Viewer Line Tool



The line has three handles that are used to adjust the location and obliquity of the line.

- The middle handle (the crosshair) is used to drag the line in horizontal and vertical directions.

- Two circles, one towards each end of the line, are used to rotate the line.

Once the line has been adjusted, the **[GO]** button is selected in the Main Viewer to initiate the scan plane change. Alternately, right-click anywhere on the real time image in the Main or Scout Viewer to initiate the scan plane change.

Draw Line for the Scout Viewer is used to prescribe a real time scan plane orthogonal to the current scout image. With Draw Line selected, clicking the Scout Viewer displays a line. The real time scan plane moves to that location. The line (Figure 13-12) displays and operates the same as the line tool for the real time image Main Viewer.

The line handles are used to position the line segment at the desired location on the Scout Viewer. The real time Main Viewer tracks the position of the line and updates the real time image as the line is adjusted. Draw Line remains active until it has been toggled off, another graphic tool is clicked, or a click is performed on the real time image in the Main Viewer.

When the **Stack** box is checked, the Multi-slice mode is enabled. Multi-slice mode is used to visualize the extent of a multiple slice (stack) acquisition.

In the Multi-slice mode, Draw Line can be used on the Main Viewer real time image or in the Scout Viewer. When a line is dropped on an image, two additional line segments are displayed (smaller than the main line). The small line segment with the two notches at either end designates the first slice in the stack. The second small line segment indicates the last location in the stack. The **mm** text box to the right of the **Stack** check box determines the distance between the two small line segments in millimeters.

2 Point Tool

The 2 Point tool allows you to define an acquisition plane by depositing two points on the current real time image or on two different real time images. The on-image Movement tools are used to navigate the real time image to deposit a point on a second image. The plane resulting from the two points is positioned midway between the points, and perpendicular to the line defined by the points. Figure 13-13 illustrates the 2 Point tool defining the scan plane perpendicular to the optic nerve. The optic nerve will be viewed on end in the resulting image of this example.

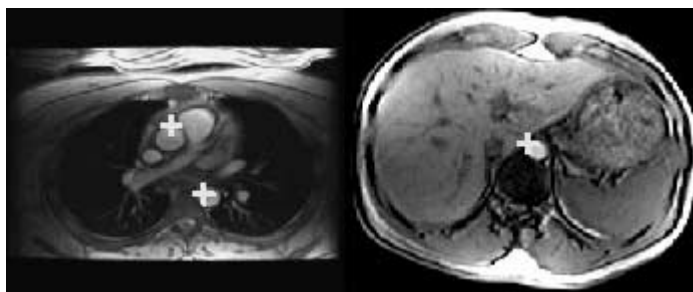
Figure 13-13 2 Point Tool Defining a Scan Plane



3 Point Tool

The 3 Point tool allows you to define an acquisition scan plane by depositing three points at selected locations on one, two, or three images. The on-image Movement tools are used to navigate the real time image to deposit a point on a second or third image. The plane resulting from these three points contains all three points. The 3 Point tool is typically used with complex anatomy that requires you to work with multiple images in a prescription. Figure 13-14 illustrates the 3 Point tool defining a scan plane along the thoracic aorta.

Figure 13-14 3 Point Tool Defining a Scan Plane



Parameter Tools

The FOV, slice thickness, flip angle, and number of averages can be changed interactively from the Acquire tab in *iDrive Pro Plus* for RTCAs. The RTCA Parameter tools (Figure 13-15) available depend on the selected pulse sequence.

Upon entering the Acquire tab, these parameters are set to the values prescribed at the Scan Rx desktop. The sliders can be used to make the change or a value can be entered in the text boxes.

Figure 13-15 RTCA Parameter Tools



Each parameter can be changed within the limits described in Table 13-4. If you enter a value that exceeds either the minimum or maximum allowed value, a default entry is made automatically. The default entry is either the minimum or maximum value, whichever is closer to the value you entered.

Table 13-4 RTCA Parameter Tool Limits

Parameter Tool	Limits
FOV	The FOV can be changed to a minimum of 50% and a maximum of 150% of the prescribed value. The change cannot exceed the minimum and maximum values based on the pulse sequence, series prescription, and system limitations. The slider and text box are based on millimeter changes (not centimeter) and when the slider is moved, changes occur in 10 mm increments. The FOV slider is not available for FGRET-RT.
Slice Thickness	The slice thickness can be changed to a minimum of 50% and a maximum of 150% of the prescribed value. The change cannot exceed the minimum and maximum values based on the pulse sequence, series prescription and system limitations. The slider changes the slice thickness in increments of 0.1 mm.
Flip Angle	The flip angle can be altered to 50% above and below the prescribed value. The flip angle cannot exceed the minimum and maximum values as determined by the pulse sequence. The slider changes the flip angle in increments of 1°.

Parameter Tool	Limits
Average	The average value defines the number of reconstructed images that are averaged to create one real time image for each new scan plane. As averages increase, SNR increases and the frame rate may decrease due to a decrease in reconstruction time. Note that this is not the same as Number of Excitations (NEX). The allowable range for image averaging is one to eight. One means that image averaging will not be performed. The value steps in increments of one. Image averaging occurs as long as the interactive scan plane and contrast settings are not changed.

Graphic Prescription Tools

iDrive Graphic Prescription (IGRx) tools can be used to:

- Save start and end locations that can then be acquired at a later time in the real time session.
- Apply start and end locations that have been scanned and saved to the IGRx tools area during a real time session.
 - These locations can be applied to a series in the Rx Manager.
- Retrieve the start and end locations from a series (2D, 3D or Real Time) in the Rx Manager that can then be acquired at a later time in the real time session.
- Apply the center of a stack to a series in the Rx Manager.
 - The stack center is used by the series to determine the start and end locations based on the coordinates of the stack center and the slice thickness and spacing of the series.
- Retrieve the center location of a 3D series to be used in the current real time session.

NOTE: The series you wish to prescribe must be downloaded in the Rx Manager and highlighted prior to starting the RTCA.

Two methods of defining imaging locations can be performed, prescribing the start and end locations and prescribing the center location. It is not possible to retrieve slice locations from an Rx Manager series in which the slice locations have been graphically prescribed. Attempting to enter the Graphic Rx screen of a series in which a RTCA was used to apply locations results in the locations erasing.

Prescribing Start and End Locations

When the **[Rx Start/End]** button is clicked, the IGRx tools (Figure 13-16) allow image locations to be defined from a start and end perspective. The start and end locations displayed are the RAS coordinates of the center point of the image.

Figure 13-16 RTCA IGRx Tools

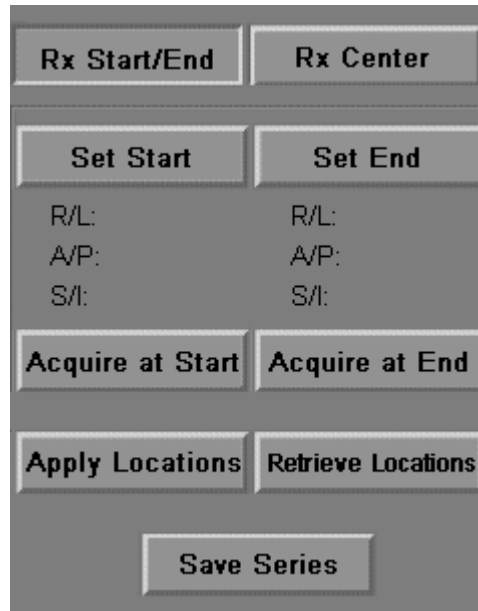


Table 13-5 lists the tools available in IGRx for RTCAs and a description of each.

Table 13-5 RTCA IGRx Tools and Descriptions

IGRx Tool	Description
[Rx Start/End]	Accesses the IGRx tools in the Rx Start/End mode.
[Rx Center]	Changes the IGRx tools area to the Rx Center mode.
[Set Start]	Saves the current position of the real time image as the first location of another series or to be used to acquire a real time image at that location. The saved start coordinates are displayed.
[Set End]	Saves the current position of the real time image as the last location of another series or to be used to acquire a real time image at that location. The saved end coordinates are displayed.

IGRx Tool	Description
[Acquire at Start]	Prompts /Drive to scan an image at the locations defined by the [Set Start] button. This button is unavailable if a start location has not been defined.
[Acquire at End]	Prompts /Drive to scan an image at the locations defined by the [Set End] button. This button is unavailable if an end location has not been defined.
[Apply Locations]	Sends the current Start/End locations to the currently highlighted series in the Rx Manager. These locations become the prescribed slice locations for that series. Slice locations already prescribed are overwritten.
[Retrieve Locations]	Pulls the start and end slice locations from a series in the Rx Manager. The RAS coordinates of the start/end locations are displayed below the [Set Start] and [Set End] buttons in the IGRx tools area. These locations can then be used to obtain real time images at those locations. If the currently selected series has no prescribed start and end locations, the locations become (or remain) undefined.
[Save Series]	Saves the prescribed series in the Rx Manager. The series is then labeled as RXD in the Rx Manager.

When defining locations using the IGRx tools, consider the following:

- The start and end locations can be redefined by clicking the **[Set Start]** and **[Set End]** buttons. If the start and end locations have been defined and one of the buttons is clicked to redefine a location, the other location responds in one of the following fashions.
 - If the plane of the new location and the old location remain parallel, the old location remains as defined.
 - If the plane of the new location and the plane of the old location are consistent, the old location is deleted. A message posts to notify you of this action.
- Start and end locations can be the same location. This may be done when the locations are to be applied to a real time series in the Rx Manager.
- When using the **[Apply Locations]** button, the applied start and end locations may be rejected if the plane of the start and end locations do not match the plane of the series to which they are being applied. For example, locations can be applied oblique to oblique, axial to axial, etc. An error message posts if an incompatibility exists.
- If the number of slice locations being applied (when using Apply Locations) exceeds the maximum number of acquisitions for the

selected series in the RX Manager, an error message results stating, “Scn: Incompatible Scan Range. Apply Ignored.”

- When using the **[Retrieve Locations]** button, if the Rx Manager series does not contain prescribed slices, the start and end coordinates remain clear.

Prescribing Center Locations

When the **[Rx Center]** button is selected during a RTCA, the IGRx tools allow image locations to be defined from a center of the stack perspective.

Figure 13-17 RTCA Center IGRx Tools

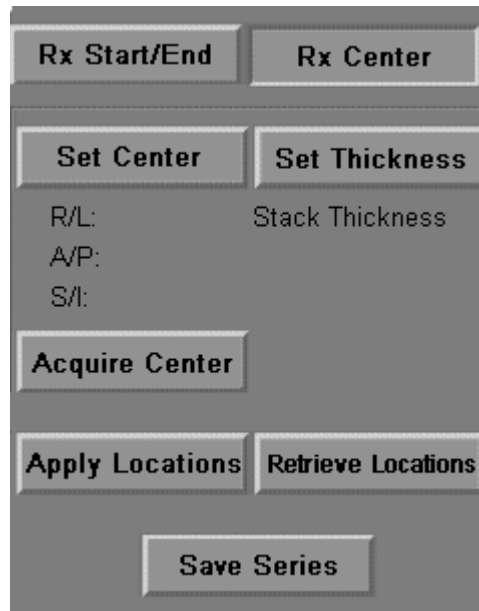


Table 13-6 lists the tools available in Center IGRx and a description of each.

Table 13-6 RTCA Center Tools and Descriptions

Center IGRx Tool	Description
[Rx Start/End]	Changes the IGRx tools area to the Rx Start/End mode.
[Rx Center]	Accesses the Rx Center IGRx tools.
[Set Center]	Saves the current position of the real time image for use as the center location for a series in the Rx Manager, or to be used to acquire a real time image at that location. The coordinates are displayed and the current stack value is entered as the Stack Thickness on the IGRx tools area.

Center IGRx Tool	Description
[Set Thickness]	Allows you to change the stack thickness after the [Set Center] button has been clicked. Enter a new value in the Stack text box and click the [Set Thickness] button. The stack value currently in the Stack text box is entered as the Stack Thickness in the IGRx tools area.
[Acquire Center]	Obtains a real time image at the location displayed in the Rx Center tools area.
[Apply Locations]	Sends the stack locations to the currently highlighted series in the Rx Manager. These locations become the prescribed slice locations for that series. Slice locations already prescribed are overwritten.
[Retrieve Locations]	Pulls the slice locations from a series in the Rx Manager. The center slice of the series is used as the center of the stack and the thickness is based on the start/end locations of the series. The center location and thickness are displayed in the IGRx tools area and can be used to obtain real time images at those locations.
[Save Series]	Saves the prescribed series in the Rx Manager. The series is labeled "RXD" in the Rx Manager.

When defining locations using the Center IGRx tools in RTCAs, consider the following:

- By convention, when the center slice and stack thickness are used to define locations, the start location in that stack is the location nearest you in the real time viewer. The end location in the stack is the furthest away from you.
- It is possible for a stack to be applied to a series in the Rx Manager and a double acquisition results for that series. For example, the series slice thickness is 5 mm, spacing is 1 mm, and the maximum number of locations per acquisitions is 11. If the applied stack is 80 mm thick, a double acquisition is required to scan the entire stack. The series can only acquire 66 mm in a single acquisition.

Review Tab

The Review tab is used to view and save real time images residing in the Image Buffer. Viewing images can be done in a cine-style, movie mode, or a single image at a time. The defined image range determines the images available to be viewed.

Clicking the Review tab on the lower left corner of the Acquire tab accesses the Review tab. The Review tab takes longer to open as the Image Buffer becomes more full. If the Review tab is clicked while data acquisition is taking place, scanning pauses. When the Review tab (Figure 13-18) opens, the image displayed is the last image displayed in the Main Viewer on the Acquire tab.

Figure 13-18 RTCA Review Tab




Table 13-7 provides a description and acceptable values for each selection on the Review tab in iDrive Pro Plus for RTCAs.

Table 13-7 RTCA Review Tab Selections and Descriptions

Selection	Description
[Delete Bookmarks]	Deletes all bookmark thumbnails currently displayed. Note that bookmarks created on the Acquire tab are shown on the Review tab. Individual bookmarks cannot be deleted.

Selection	Description
[Add Bookmarks]	The plane, location, and image contrast of the image currently in the Review tab viewer is saved as a bookmark thumbnail for later recall. Bookmarks can be created and deleted in both the Acquire and Review tabs.
[Define Scout]	Copies the image in the Main Viewer to the Scout Viewer (the viewer directly under the [Define Scout] button). The new scout is also applied to the Scout Viewer on the Acquire tab.
[Define New Home]	Inactive on the Review tab.
[Pause When Full]	Automatically pauses the real time data acquisition when the real time image buffer is full. The progress bar provides a graphic display of the image buffer capacity.
[Save Image]	Saves the image in the Review tab Main Viewer to the system disk. When a saved image is displayed, the word "Saved" is seen below this button.
Image Slider	Allows you to move through the images to change the image currently displayed in the viewer.
Play Back Button: Play Forward 	Starts a movie in a forward play motion. The images are displayed in movie playback in ascending image number order, starting at the first image in the defined range. The Image Slider updates to reflect the image that is currently being viewed.
Play Back Button: Stop Play 	Stops the movie playback. You can also stop playback by pressing the selected toggle that started play.
Play Back Button: Play Backward 	Starts a movie in a backward play motion. The images are displayed in movie playback in descending image number order, starting at the last image number defined in the image range. Play continues according to the temporal or spatial play mode selected.
[Temporal]	Plays the movie images in a continuous loop from first to last. When the end of the range is reached, play wraps to the first image again. For example, an image set consisting of four images appears in the following order: 1, 2, 3, 4, 1, 2, 3, 4, etc.

Selection	Description
[Spatial]	Plays the movie images forward, then backward in a repeating loop. Image play effectively "bounces" off the end of the range in a forward and backward direction. For example, an image consisting of four images appears in the following order:1, 2, 3, 4, 3, 2, 1, etc.
FPS	Frames per Second (FPS) defines the rate of movie playback. The valid range is 1 to 60 FPS. If you enter a value higher than the system allows, the maximum allowed value of 60 is displayed.
[Set Range First]	Defines the first image to be included in a range for saving, or set of images for displaying in movie mode.
[Set Range Last]	Defines the last image to be included in a range for saving, or set of images for displaying in movie mode.
[Full Annotation]	Displays all image annotation in the main viewer. Otherwise, only partial annotation is displayed.
[Measure Distance]	Displays a line on the main image. The length and angle of the line can be adjusted by dragging either end. You can change the line location by clicking and dragging anywhere, other than the ends of the line. The line length and angle from vertical is displayed on the image.
[Save Range]	Saves the range of images defined on the Review tab to the system disk. As the images are being saved, a status box displays, counting down the number of images yet to be saved. You can cancel the save during the save operation. When a saved image is displayed in the Main Viewer, the word "Saved" is seen below the [Save Image] button.
[Acquire at Current]	Returns the display to the iDrive Acquire tab and begins data acquisition at the image location currently displayed in the Review tab Main Viewer.
[Acquire]	Returns the display to the iDrive Acquire tab.
Message Area 	Displays messages at the bottom of the Review tab. Click the button to display a list of messages for the current real time session.
[Close]	Exits the Review tab, stops the current real time session, and returns to the Scan Rx desktop.

Review Images

Real time images are not automatically saved to the system disk. The **[Save Image]** button is used to save a single 128x128 image to the disk when that image is displayed in the Acquire tab Main Viewer, or via the **[Save Image]** or **[Save Range]** buttons on the Review tab. When a saved image is displayed in the Review tab, the word "Saved" is seen below the **[Save Image]** button. This is not true when displaying images in the Acquire tab.

Bookmarks in the Review tab cannot be used to initiate data acquisition as can be done in the Acquire tab.

Annotation on the real time image indicates the parameters with which that image was acquired, including those parameters changed at the Acquire tab. Partial annotation (Table 13-8) is displayed, unless you click the **[Full Annotation]** button.

Table 13-8 Partial Annotation Selections

Partial Annotation Selections
System
Hospital
Time
Magnification, Filtering, and Rotation Factors
PSD
Sequence Parameters
Slice Thickness and Spacing

Image Slider

Images currently in the real time Image Buffer can be displayed using the Image Slider (Figure 13-19). The Image Slider is set to the number of the last real time image acquired before pausing. The image displayed on the viewer is the same image. The Image Slider can define or redefine the image range that is used for saving or playing real time images.

Figure 13-19 Image Slider



There are four ways to move through the images in the Review tab and select an image number for display.

- Dragging the slider.
 - As the slider moves, the image in the viewer updates to the image on the slider.
- Clicking the arrows at either end of the slider.
- Clicking the slider background.
 - This displays the image associated with that point on the slider.
- Pressing the **Page Up** and **Page Down** hard keys on the keyboard.

Within Review, the operations of playing and saving images are applied to a single defined range of images within the image buffer. The number of the image currently shown in the viewer is labeled above the slider, as well as, on the image. At both ends of the slider the range of images is also displayed. Upon entering the Review tab, the range of images indicates all the images in the buffer. The image numbers shown indicate how many images have been acquired during the real time session; therefore, they may be numbered in the hundreds or thousands.

The background of the slider is shaded to indicate the range of images defined by the Set Range buttons. Initially, the background is completely shaded. If the range of images is changed, only the area of the slider associated with the image range is shaded. If an attempt is made to set the first image in the range to a value greater than the currently defined last image in the range, the first and last images are swapped.

Applications

The RTCA application consists of a continuous high-temporal-resolution acquisition, reconstruction, and display of low spatial resolution images. This allows you to instantaneously view anatomy and interactively make contrast adjustments and prescribe scan planes. Real time imaging works well to monitor temporal physiological events, including patient breathing and bolus or perfusion activity.

Use real time imaging to:

- Navigate through patient anatomy for orientation to “scope out the lay of the land.”
- Rapidly localize anatomical landmarks of interest.
- Define the boundaries of an imaging volume.
- Localize complex anatomy or anatomical anomalies that lie in double oblique planes.
- Monitor temporal events such as the passage of a contrast timing bolus.
- Image dynamic joint studies.
- Know what the scan looks like before investing the scan time.

Troubleshooting Tips

The following section gives you tips for troubleshooting errors when scanning RTCAs with *iDrive* Pro Plus.

If you click the **[Scan]** button too quickly following pressing the **Stop Scan** hard key and closing the RTCA interface, *iDrive* is not prepared to begin data acquisition. An error message posts, "Prep action failed, please try again."

For example, the following scenario may result in the failure to start a real time data acquisition.

1. A real time acquisition is paused by selecting the **[Pause Scan]** button at the Acquire tab.
2. The **Stop Scan** hard key on the keyboard is pressed.
3. The **[Close]** button is selected at the Acquire tab and the real time interface closes.
4. The **[Scan]** button is clicked at the Scan Rx desktop quickly after the real time interface closes.

At this time, the real time data acquisition should be initiated. Instead, the error message posts because *iDrive* is not ready to begin the data acquisition.

Error messages posted in the message log also include:

- Proc: scn Error: XXXXXXXXXXX
- Unexpected allocDone packet received from IFCC for sequence number XX. Proc: NSP Error: XXXXXXXXXXX
- An unexpected CERD Network packet was received by ASC Data Acquisition during acquisition.
- Internal software error, please retry the acquisition!

Should it be necessary for you to stop a scan and close *iDrive* as stated in the steps above, it is recommended the real time series be copied and pasted and the data acquisition be started from the new series.

Alternatively, wait a period of time before selecting the **[Scan]** button and re-starting the real time acquisition. The exact amount of time needed for *iDrive* to be ready is not known. It is recommended that you wait at least five seconds before restarting the acquisition.

How Do I...

This section provides the step-by-step instructions for imaging real time with iDrive Pro Plus. Specifically, it describes how to:

- Prescribe a real time sequence
- Use the Movement tools
 - Drive through an image volume
 - Step through an image volume
- Manage Home Images
 - Define a scan plane
 - Define new Home Images
- Manage Bookmarks
 - Create a Bookmark
 - Recall a Bookmark
 - Enlarge a thumbnail to apply for scanning
- Use the Graphic tools
 - Change the FOV center
 - Draw a line in the Main Viewer
 - Draw a line in the Scout Viewer
 - Draw a line in the Multi-slice Mode
 - Apply the 2 Point tool
 - Apply the 3 Point tool
- Review real time images
 - Playback images
 - Save images

Prescribe a Real Time Sequence

The Real Time Imaging Option can be used for RTCAs to navigate through your patient's anatomy for rapid visualization and monitoring of temporal physiological events. Real time images can also be used for directly prescribing scan planes of other series in the exam.

Use this procedure to prescribe a real time sequence. The PSD you select determines which values in each area need entered. You need to enter a value in all active fields.

1. Click **[New Series]**.
 - ◆ Located in the Rx Manager.
2. Enter the Patient Position parameters.
 - ◆ Patient Position
 - ◆ Patient Entry
 - ◆ Coil
 - Real Time is compatible with all coils. The use of a phased array coil may decrease the frame rate as compared to a single receive coil.
 - ◆ Series Description
3. Enter the Imaging Parameters.
 - ◆ Plane
 - Real Time can be initiated in any orthogonal plane. Oblique planes may be prescribed using an explicit coordinate entry or from localizer images using Graphic Rx tools.
 - ◆ Mode
 - 2D is the only valid mode with Real Time.
 - ◆ Gradient Mode
 - Real Time is compatible with any gradient mode.
 - ◆ Pulse Sequence
 - PSDs available with *i*Drive Pro Plus: Fast GRE, Fast SPGR, Fast GRE ET, Spiral GRE, and Spiral SPGR

In Brief: Prescribe a Real Time Sequence

1. Click **[New Series]**.
2. Enter the Patient Position parameters.
3. Enter the Imaging Parameters.
4. Enter the Scan Timing parameters.
5. Enter the Scanning Range parameters.
6. Enter the Acquisition Timing parameters.
7. Click **[Save Series]**.
8. Click **[Prepare to Scan]**.
9. Click **[Scan]**.

- ◆ Imaging Options
 - Real Time must be selected to enter the feature.
 - Other compatible options are Flow Compensation and No Phase Wrap.
- 4. Enter the Scan Timing parameters.
 - ◆ TE
 - ◆ TR
 - ◆ Flip Angle
 - ◆ Echo Train Length
 - ◆ Bandwidth
- 5. Enter the Scanning Range parameters.
 - ◆ FOV
 - ◆ Slice Thickness
 - This value can be changed during *i*Drive Pro Plus data acquisitions.
 - ◆ Start and End Locations
 - Only one slice location is allowed for real time sequences.
- 6. Enter the Acquisition Timing parameters.
 - ◆ Frequency Matrix or Points
 - ◆ Phase Matrix or Arms
 - ◆ Phase FOV
 - ◆ Freq DIR
 - ◆ Auto Center Frequency
- 7. Click [**Save Series**].
 - ◆ Closes the scan prescription screen, accepts the prescription, and saves it in the Rx Manager as RXD.
- 8. Click [**Prepare to Scan**].
 - ◆ Downloads the series.
- 9. Click [**Scan**].
 - ◆ Initiates Auto Prescan and the Acquire tab opens.
 - ◆ Home Images are acquired.

Use the Movement Tools

Drive Through an Image Volume

The scan plane of your RTCA can be manipulated and you can navigate through an image volume using the Movement tools. Each Movement tool is activated by an on-image icon on the real time Main Viewer. RTCAs begin in the Drive mode with the Translate tool active.

1. Move the mouse over the real time image in the Main Viewer until the cursor changes shape.
2. Click in Tool Selection area of desired tool.
 - ♦ Cursor icon indicates the function of the tool.
3. Click and drag on the real time image in the Main Viewer.
 - ♦ Your cursor indicates the direction of movement by displaying the icon associated with that tool accessed in that corner and the image moves in the direction of the cursor.
 - ♦ The extent of movement is annotated in the lower-right corner of the real time image.
 - a) Move the cursor to the upper-left corner.
 - Activates the Pan tool to scroll the image in the X and Y directions.
 - b) Move the cursor to the upper-right corner.
 - Activates the Rotate tool to turn the image in a clockwise or counter-clockwise motion.
 - c) Move the cursor in the lower-left corner.
 - Activates the Tilt tool to roll the image in the direction of the arrow on the cursor.
 - d) Move the cursor in the lower-right corner.
 - Activates the Translate tool to oblique the image along the Z axis, tilting the image away from you.
4. Release the mouse button.
 - ♦ The scan plane of the real time image updates.

NOTE: Click **[Undo]** to cancel the location changes all the way back to the start of motion, at the last mouse click.

In Brief: Drive Through an Image Volume

1. Move the mouse over the real time image in the Main Viewer until the cursor changes shape.
2. Click in Tool Selection area of desired tool.
3. Click and drag on the real time image in the Main Viewer.
4. Release the mouse button.

Use the Movement Tools

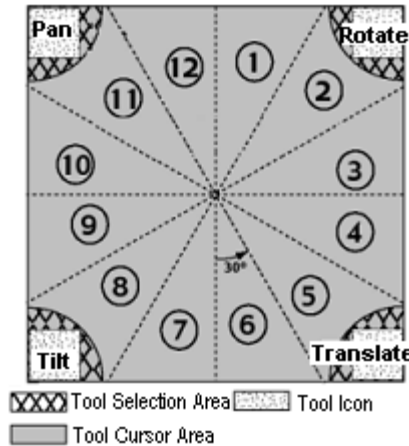
Step Through an Image Volume

In Brief: Step Through an Image Volume

1. Click [**Step**].
2. Click in Tool Selection area of desired tool.
3. Click and hold on the real time image in the Main Viewer.
4. Release the mouse button.

The scan plane can also be manipulated using the Movement tools accessed in the Step mode for RTCAs. In the Step mode, the cursor indicates the direction of movement, but movement direction changes depending on the location of the cursor in the Main Viewer.

1. Click [**Step**].
 - ◆ Your cursor location determines the direction of movement.
 - ◆ Movement direction changes when a specific tool is used at that point on the image.
2. Click in Tool Selection area of desired tool.
 - ◆ Cursor indicates direction of motion that will be induced.



Control Zones and Location of Scan Controls

3. Click and hold on the real time image in the Main Viewer.
 - ◆ An on-image counter displays, indicating the millimeters or degrees of the scan plane change that takes place as long as the mouse button is held down.
- a) Click one of the twelve zones on the image in the Main Viewer.
 - Activates the Pan and Tilt tools to move the image in the X and Y directions based on the value in the **mm** or the **degrees** text box, respectively.

- b) Click in the right-half of the Main Viewer to move clockwise or in the left-half to move counter-clockwise.
 - Activates the Rotate tool to turn the image based on the value set in the **degrees** text box.
 - c) Click in the upper-half of the Main Viewer to move the image away from you or in the lower-half to move the image towards you.
 - Activates the Translate tool to oblique the image along the Z axis, moving the image away or towards you based on the value set in the **mm** text box.
4. Release the mouse button.
- ♦ Applies the value on the counter to move the scan plane of the real time image that amount.
 - ♦ The scan plane of the real time image updates.

NOTE: Click **[Undo]** to cancel the location changes all the way back to last mouse click.

Manage Home Images

Define a Scan Plane

In Brief: Define a Scan Plane

1. Prescribe a real time sequence.
2. Click **[Scan]**.
3. Click one of the Home Images.

Home Images are the three orthogonal images acquired upon initialization of a real time series that are displayed in the vertical viewers along the right side of the Acquire tab Main Viewer. The Home Images are created axially, sagittally, and coronally, based on the locations prescribed at the Scan Rx desktop during the real time series prescription. These images can be used to define an orthogonal scan plane and reset your current scan plane.

Use this procedure to define a scan plane based on the Home Images.

1. Prescribe a real time sequence.
2. Click **[Scan]**.
 - ◆ Acquire tab opens.
 - ◆ Home Images are acquired.
3. Click one of the Home Images.
 - ◆ The system obtains a real time image in the scan plane of the selected Home Image.

Manage Home Images

Define New Home Images

Home Images are the three orthogonal images acquired upon initialization of a real time series that are displayed in the vertical viewers along the right side of the Acquire tab Main Viewer. The Home Images are created axially, sagittally, and coronally, based on the locations prescribed at the Scan Rx desktop during the real time series prescription. You have the ability to define new Home Images.

Use this procedure to replace your Home Images with new images at the desired at the location of the current real time image.

1. Display the desired real time image in the Main Viewer.
 - ◆ Use the Movement tools, if necessary.
2. Click **[Define New Home]**.
 - ◆ Located at the top-right corner of the Acquire tab.
 - ◆ The system informs you that if you define new Home Images, your current home locations will be replaced.
3. Click **[OK]**.
 - ◆ The system acquires and displays three new Home Images.
 - The images are perpendicular to the location of the real time image in the Main Viewer.
 - The images include the RAS offsets of the real time image in the Main Viewer.

In Brief: Define New Home Images

1. Display the desired real time image in the Main Viewer.
2. Click **[Define New Home]**.
3. Click **[OK]**.

Manage Bookmarks

Create a Bookmark

In Brief: Create a Bookmark

1. Display the desired real time image in the Main Viewer.
2. Click **[Add Bookmark]**.

Real time images can be bookmarked to recall at a later time. A bookmarked thumbnail obtains the scan plane and image contrast from that image and stores it in the Bookmark Viewers.

Use this procedure to create a Bookmark.

1. Display the desired real time image in the Main Viewer.
 - ♦ Use the Movement Tools, if necessary.
2. Click **[Add Bookmark]**.
 - ♦ Creates a bookmark thumbnail of the current image in the Main Viewer.

NOTE: If all Thumbnail Viewers are filled, a message posts, telling you to right-click an occupied Bookmark to replace the thumbnail image with the current image in the Main Viewer.

Manage Bookmarks

Recall a Bookmark

A recall can be performed on a bookmark to obtain the scan plane and image contrast from that image. The bookmarks are held in the Acquire tab when the current real time session is closed and upon re-entry into the RTCA, those bookmark thumbnails are displayed as long as the Patient ID, Landmark, and Patient Position have not changed.

Use this procedure to recall a Bookmark.

1. Click **[Scan]**.
 - ◆ Acquire tab opens.
2. Click the desired bookmark thumbnail image.
 - ◆ The system scans the new image based on the scan plane and image contrast of the thumbnail image.

In Brief: Recall a Bookmark

1. Click **[Scan]**.
2. Click the desired bookmark thumbnail image.

In Brief: Enlarge a Thumbnail to Apply for Scan

1. Place cursor over desired thumbnail image.
2. Click the enlarged image.

Manage Bookmarks

Enlarge a Thumbnail to Apply for Scan

A single bookmark thumbnail image acquired during a RTCA with *iDrive Pro Plus* can be enlarged from a 64x64 to 128x128 pixel display. This enlarged thumbnail can be applied for scanning in the real time Main Viewer.

Use this procedure, while the Acquire tab is opened, to enlarge a bookmark thumbnail to apply for scanning.

1. Place cursor over desired thumbnail image.
 - ◆ Leave cursor over thumbnail for at least one second.
 - The image enlarges.
 - ◆ The thumbnail image returns to its original size when the cursor is moved off the Thumbnail Viewer.
2. Click the enlarged image.
 - ◆ The system begins scanning the image.

Use the Graphic Tools

Change the FOV Center

The Graphic tools provide a means by which you can define a new real time image location. The Center tool in iDrive Pro Plus changes the FOV center of the real time image of a RTCA to a new location. This Graphic tool is located in the Tool area of the Acquire tab.

Use this procedure to change the FOV center of the real time image to the location of a cursor placed on the real time image.

1. Display the desired real time image in the Main Viewer.
 - ♦ Use the Movement tools, if necessary.
2. Click **[Center]**.
3. Place the cursor at the desired FOV center.
 - ♦ This point will be the center of your new image location.
4. Click the real time image.
 - ♦ Updates real time image to reflect the new FOV center at the point of the cursor.

NOTE: The Center tool turns off automatically.

In Brief: Change the FOV Center

1. Display the desired real time image in the Main Viewer.
2. Click **[Center]**.
3. Place the cursor at the desired FOV center.
4. Click the real time image.

In Brief: Draw a Line in the Main Viewer

1. Display the desired real time image in the Main Viewer.
2. Click **[Draw Line]**.
3. Move the line to the desired position.
4. Rotate the line to the desired position.
5. Click **[GO]**.

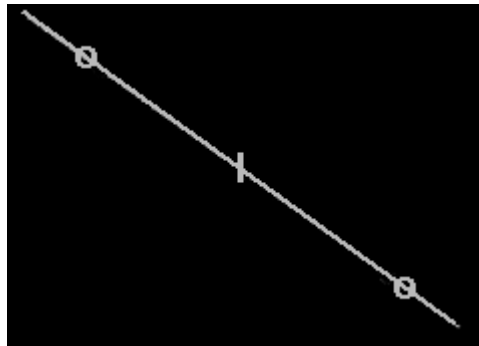
Use the Graphic Tools

Draw a Line in the Main Viewer

The Draw Line tool allows you to draw a line on the current real time image in the Main Viewer to acquire an image at the plane of the line. This Graphic tool is located in the Tool area of the Acquire tab.

Use this procedure to draw a line on the real time image in the Main Viewer to define a new scan plane.

1. Display the desired real time image in the Main Viewer.
 - ♦ Use the Movement tools, if necessary.
2. Click **[Draw Line]**.
 - ♦ A line appears on the image in the Main Viewer.
 - If a line does not appear, click on the real time image.



Draw Line Tool

3. Move the line to the desired position.
 - ♦ Click and drag the middle handle of the line.
 - Moves the line in the horizontal and vertical directions.
4. Rotate the line to the desired position.
 - ♦ Click and drag one of the circle handles of the line.
 - Rotates the line clockwise or counter-clockwise.
5. Click **[GO]**.
 - ♦ Alternatively, you may right-click anywhere on the real time image.
 - ♦ An image is acquired at the plane defined by the line.

NOTE: Draw Line remains active until you toggle it off, click another Graphic tool, or a click on the Scout image.

Use the Graphic Tools

Draw a Line in the Scout Viewer

The Draw Line tool for the Scout Viewer in iDrive Pro Plus allows you to prescribe a new acquisition plane orthogonal to the current Scout image. This Graphic tool is located in the Tool area of the Acquire tab.

Use this procedure to draw a line on the real time image in the Scout Viewer.

1. Display the desired real time image in the Main Viewer.
 - ♦ Use the Movement tools, if necessary.
2. Click **[Define Scout]**.
 - ♦ Copies the image in the Main Viewer to the Scout Viewer.
3. Click **[Draw Line]**.
4. Click the image in the Scout Viewer.
 - ♦ A line appears on the image in the Scout Viewer.
 - ♦ The real time image scan plane moves to that location.
5. Move the line to the desired position.
 - ♦ Click and drag the middle handle of the line.
 - Moves the line in the horizontal and vertical directions.
 - Updates the real time image to reflect changes.
6. Rotate the line to the desired position.
 - ♦ Click and drag one of the circle handles of the line.
 - Rotates the line clockwise or counter-clockwise.
 - Updates the real time image to reflect changes.

NOTE: Draw Line remains active until you toggle it off, click another Graphic tool, or a click on the real time image in the Main Viewer.

In Brief: Draw a Line in the Scout Viewer

1. Display the desired real time image in the Main Viewer.
2. Click **[Define Scout]**.
3. Click **[Draw Line]**.
4. Click the image in the Scout Viewer.
5. Move the line to the desired position.
6. Rotate the line to the desired position.

In Brief: Draw a Line in the Multi-Slice Mode

1. Display the desired real time image in the Main Viewer.
2. Select **Stack**.
3. Click [**Draw Line**].
4. Click the image in the Main or Scout Viewer.
5. Enter a value in the **mm** text box.

Use the Graphic Tools**Draw a Line in the Multi-slice Mode**

Multi-slice mode is used to visualize the extent of a multiple slice (stack) RTCA in iDrive Pro Plus. Drawing a line in the Multi-slice mode can be performed in the Main Viewer or in the Scout Viewer. This Graphic tool is located in the Tool area of the Acquire tab and the Stack option is located below the tools.

Use this procedure to draw a line in the Multi-slice mode to visualize the distance of a multi-slice acquisition.

1. Display the desired real time image in the Main Viewer.
 - ♦ Use the Movement tools, if necessary.
2. Select **Stack**.
 - ♦ Enables Multi-slice mode.
3. Click [**Draw Line**].
4. Click the image in the Main or Scout Viewer.
 - ♦ A line appears on the real time image.
 - ♦ Two smaller line segments display (smaller than the main line).
 - The small line segment with two notches at either end indicates the first slice in the stack.
 - The second small line segment indicates the last location of the stack.
5. Enter a value in the **mm** text box.
 - ♦ Acceptable values are 10 to 100.
 - ♦ This value determines the distance between the two small line segments.

Use the Graphic Tools

Apply the 2 Point Tool

The 2 Point Tool allows you to define an acquisition plane by depositing two points on the current real time image or on two different real time images. The plane resulting from the two points is positioned midway between the points and orthogonal to the line defined by the points. This Graphic tool is located in the Tool area of the Acquire tab.

Use this procedure to define an acquisition plane perpendicular to a line deposited by two points.

1. Display the desired real time image in the Main Viewer.
 - ◆ Use the Movement tools, if necessary.
2. Click **[2 Point Tool]**.
 - ◆ Two toggle buttons appear.
 - Point 1 (toggled on)
 - Point 2
3. Place the cursor at the point you wish to deposit Point 1 on the real time image.
4. Click the real time image.
 - ◆ Deposits Point 1.
 - ◆ Toggles the **[Point 1]** button off.
 - Clicking **[Point 1]** again allows the point to be repositioned.
5. Navigate to the desired image plane for Point 2.
 - ◆ Use the Movement tools, if necessary.
6. Click **[Point 2]**.
7. Place the cursor at the point you wish to deposit Point 2 on the real time image.
8. Click the real time image.
 - ◆ Deposits Point 2.
 - ◆ Acquires an image perpendicular to the line connecting the two points and displays the new image.

NOTE: The 2 Point Tool turns off automatically.

In Brief: Apply the 2 Point Tool

1. Display the desired real time image in the Main Viewer.
2. Click **[2 Point Tool]**.
3. Place the cursor at the point you wish to deposit Point 1 on the real time image.
4. Click the real time image.
5. Navigate to the desired image plane for Point 2.
6. Click **[Point 2]**.
7. Place the cursor at the point you wish to deposit Point 2 on the real time image.
8. Click the real time image.

In Brief: Apply the 3 Point Tool

1. Display the desired real time image in the Main Viewer.
2. Click **[3 Point Tool]**.
3. Place the cursor at the point you wish to deposit Point 1 on the real time image.
4. Click the real time image.
5. Navigate to the desired image plane for Point 2.
6. Click **[Point 2]**.
7. Place the cursor at the point you wish to deposit Point 2 on the real time image.
8. Click the real time image.
9. Navigate to the desired image plane for Point 3.
10. Click **[Point 3]**.
11. Place the cursor at the point you wish to deposit Point 3 on the real time image.
12. Click the real time image.

Use the Graphic Tools

Apply the 3 Point Tool

The 3 Point Tool allows you to define an acquisition scan plane by depositing three points at selected locations on one, two, or three images. The image plane resulting from these three points contains all three points. This Graphic tool is located in the Tool area of the Acquire tab.

Use this procedure to define a cut plane when you need to use more than one image location and you want an image plane along the plane defined by the points.

1. Display the desired real time image in the Main Viewer.
 - ◆ Use the Movement tools, if necessary.
2. Click **[3 Point Tool]**.
 - ◆ Three toggle buttons appear.
 - Point 1 (toggled on)
 - Point 2
 - Point 3
3. Place the cursor at the point you wish to deposit Point 1 on the real time image.
4. Click the real time image.
 - ◆ Deposits Point 1.
 - ◆ Toggles the **[Point 1]** button off.
 - Clicking **[Point 1]** again allows the point to be repositioned.
5. Navigate to the desired image plane for Point 2.
 - ◆ Use the Movement tools, if necessary.
6. Click **[Point 2]**.
7. Place the cursor at the point you wish to deposit Point 2 on the real time image.
8. Click the real time image.
 - ◆ Deposits Point 2.
 - ◆ Toggles the **[Point 2]** button off.
 - Clicking **[Point 2]** again allows the point to be repositioned.

9. Navigate to the desired image plane for Point 3.
 - ◆ Use the Movement tools, if necessary.
10. Click **[Point 3]**.
11. Place the cursor at the point you wish to deposit Point 3 on the real time image.
12. Click the real time image.
 - ◆ Deposits Point 3.
 - ◆ Acquires and displays the new image.

NOTE: The 3 Point Tool turns off automatically.

In Brief: Playback Images

1. Click **[Review]**.
2. Define the range of images for movie playback.
3. Select the movie mode.
4. Enter a value in the **FPS** text box.
5. Click the **Play Forward** or the **Play Backward** icon.
6. Click the **Stop** icon.

Review Real Time Images Playback Images

Real time images residing in the Image Buffer can be viewed in the Review tab. Images can be viewed cine-style, in a movie mode, or by a single image at a time. The Review tab is accessed on the lower left corner of the Acquire tab and can be opened while scanning is taking place.

Use this procedure to playback images in the Image Buffer.

1. Click **[Review]**.
 - ◆ Pauses scanning.
 - ◆ Opens the Review tab.
2. Define the range of images for movie playback.
 - ◆ All images in the buffer can be viewed. If this is desired, continue with step 3.
 - a) Click and drag the Image Slider to the first image.
 - b) Click **[Set Range First]**.
 - c) Click and drag the Image Slider to the last image.
 - d) Click **[Set Range Last]**.
3. Select the movie mode.
 - ◆ Click **[Temporal]**.
 - Plays images in a continuous loop.
 - ◆ Click **[Spatial]**.
 - Plays images forward, then backward.
4. Enter a value in the **FPS** text box.
 - ◆ Defines the rate of movie playback.
 - ◆ Valid entries are 1 to 60.
5. Click the **Play Forward** or the **Play Backward** icon.
 - ◆ Starts movie playback in ascending or descending order, respectively.
6. Click the **Stop** icon.
 - ◆ Stops movie playback.
 - ◆ At this point, another range of images can be defined.

Review Real Time Images

Save Images

Real time images are not automatically saved to the system disk. Real time images residing in the Image Buffer can be saved in the Review tab. An image group or a single image can be saved at one time. The Review tab is accessed on the lower left corner of the Acquire tab and can be opened while scanning is taking place.

Use this procedure to save images in the Image Buffer.

1. Click **[Review]**.
 - ♦ Pauses scanning.
 - ♦ Opens the Review tab.
2. Define the range of images for saving.
 - ♦ All images in the buffer can be saved. If this is desired, continue with step 3.
 - a) Click and drag the Image Slider to the first image.
 - b) Click **[Set Range First]**.
 - c) Click and drag the Image Slider to the last image.
 - d) Click **[Set Range Last]**.
3. Click **[Save Range]**.
 - ♦ A confirmation message appears showing the number of images to be saved.
 - ♦ Saves images to the Browser list.
 - ♦ Alternatively, images can be saved one at a time.
 - Display images in the viewer.
 - Click **[Save Image]**.

In Brief: Save Images

1. Click **[Review]**.
2. Define the range of images for saving.
3. Click **[Save Range]**.

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Chapter 14

FuncTool

Introduction

FuncTool is a post processing tool used to display advanced level Magnetic Resonance Imaging (MRI) and Magnetic Resonance Spectroscopy (MRS) images. Specially designed algorithms programmed into FuncTool protocols can be used to portray various pixel intensity settings.

This chapter explains the PROstate Spectroscopy Exam (PROSE) post processing techniques. You must first acquire a PROSE sequence in order to perform any of these post processing techniques. (Refer to the Clinical Spectroscopy chapter in this guide for information on how to perform a PROSE sequence.) This chapter contains the step-by-step instructions to help you learn how to:

- Display 3D PROSE Images
- Create 3D PROSE Custom Protocols

In addition, this chapter answers the following questions:

1. What are the prostate algorithms?
2. What type of image sets can be processed with FuncTool?

What Do I Need to Know About...

This section presents the concepts necessary to successfully complete the FuncTool process for the PROSE sequence. Specifically you need to understand:

- Description of FuncTool
- Valid Image Set
- Algorithms
 - Choline
 - Creatine
 - Creatine + Choline
 - Choline/Creatine
 - Lipid and Lactate
 - Citrate
 - Choline + Creatine/Citrate
 - Composite Image
 - Signal Over Noise Ratio

Description of FuncTool

FuncTool is an optional image analysis software package, that processes dynamic image data to generate information with regard to changes in image intensity over time in the form of graphs and parametric images.

Valid Image Set

An MRS data set is an ordered acquisition with sequential changes in frequency. The horizontal scale of a graph for such a data set represent parts per million (ppm values.) PROSE sequences qualify as a valid image data set.

Algorithms

A brief description of the PROSE protocols is listed in Table 14-1.

Table 14-1 PROSE Protocols And Descriptions

Protocols	Descriptions
Choline	Displays the averaged, absolute pixel values from PROSE images 64 to 74 as a metabolite map.
Creatine	Displays the averaged, absolute pixel values from PROSE images 78 to 88, as a metabolite map.
Creatine + Choline	Displays the sum of pixel values from PROSE images 66 to 85, as a metabolite map.
Lipid and Lactate	Displays the sum of pixel values from PROSE images 183 to 222, as a metabolite map.
Citrate	Displays the averaged, absolute pixel values from PROSE images 95 to 114, as a metabolite map.
Choline + Creatine/Citrate	Displays a map of the ratio of the Choline + Creatine, images 66-85 compared to Citrate, images 95-114.
Composite image	???
Signal Over Noise Ratio	????

How Do I...

This section provides the step-by-step instructions for using FuncTool to display a PROSE sequence. Specifically, it describes how to:

- Post Processing PROSE Images with FuncTool
 - Displaying PROSE images
 - Displaying Regions of Interest

In Brief: Display PROSE Images

1. Click the **Display Desktop** icon.
2. Select your 3D PROSE series.
3. Click **[FuncTool]**.
4. Select an appropriate localizer series.
5. Select the appropriate localizer image.
6. Click **[OK]**.
7. Click **[Get Protocol] >** desired metabolite map.
8. Right click in each viewport, to save image (if desired).
9. Select **Save Image**.
10. Repeat steps 8 & 9 for remaining viewports you want saved.

Post Processing PROSE Images with FuncTool Displaying PROSE Images

Use this procedure to display the 3D PROSE images that you obtained during scanning. The prerequisites for display are a valid image set of 3D PROSE images.

1. Click the **Display Desktop** icon.
2. Select your 3D PROSE series.
 - ◆ Located in the series section of you Browser.
 - ◆ This prepares the series for download into the FuncTool display software.
3. Click **[FuncTool]**.
 - ◆ This launches your selected series into the FuncTool software.
 - ◆ Message windows appears.
4. Select an appropriate localizer series.
5. Select the appropriate localizer image.
6. Click **[OK]**.
 - ◆ This opens the Display Tool Command window.
 - ◆ If **[Cancel]** is clicked the display will discontinue.

NOTE: Refer to the 3D Focal CSI Display chapter in the ASP@ New Features guide for additional information on viewports and FuncTool display commands.

The image in the Upper Left (UL), Lower Left (LL), and the Lower Right (LR) viewports default to the first image of the selected PROSE series.

7. Click **[Get Protocol] >** desired metabolite map.
 - ◆ This displays the metabolite map and map overlay.
8. Right click in each viewport, to save image (if desired).
 - ◆ This opens the shortcut window.
9. Select **Save Image**.
 - ◆ This saves this image for later viewing in the Browser.
10. Repeat steps 8 & 9 for remaining viewports you want saved.

Post Processing PROSE Images with FuncTool Displaying Regions of Interest

In Brief: Displaying Regions of Interest

1. Select an ROI.
2. Click on image in viewport you wish to work with.
3. Page through and place multiple ROIs on any of the slices.
4. Right click in the UR viewport, choose **List Values**.
5. Click and drag any of the square handles on the ROI.
6. Click and drag the center ROI.
7. Place cursor in the UL viewport, press spacebar.
8. Click **[Split ROI]**.
9. Click the UR viewport.
10. Right click and select **X Unit > ppm**.
11. In the UR viewport change number of pixel to one.

It is not necessary that you perform the next steps if displaying the images with a metabolite map is all you want to do. Follow these steps to select specific Regions of Interest (ROIs) and obtain metabolite information for these areas. You must, however perform these step following the Displaying PROSE Images procedure.

1. Select an ROI.
 - ◆ Located on the Display Tool Command window.
 - ◆ Choose elliptical for a circular ROI.
 - ◆ Choose square for a square ROI.
 - ◆ Choose spline to draw your own ROI shape.
2. Click on image in viewport you wish to work with.
 - ◆ This deposits ROI on that image.
 - ◆ ROIs will be displayed on remaining viewports.
3. Page through and place multiple ROIs on any of the slices.
 - ◆ ROIs will be numbered consecutively, even if they are placed on multiple slices.
 - ◆ Maximum number of ROI on one image is 12. If you place more then 12 ROIs, the data is replaced for previous ROIs. For example, ROI number 13 replaces the data for ROI number one. ROI number 14 replaces the data for ROI number two, and so on.
4. Right click in the UR viewport, choose **List Values**.
 - ◆ Displays all data for prescribed ROIs.
5. Click and drag any of the square handles on the ROI.
 - ◆ Use this step to re-size ROI coverage.
6. Click and drag the center ROI.
 - ◆ Use this step to reposition the ROI.
7. Place cursor in the UL viewport, press spacebar.
 - ◆ This scales the spectral grid.

8. Click [**Split ROI**].
 - ◆ This splits ROIs into multiple ROIs.
 - ◆ To undo this step click [**Merge ROI**].
9. Click the UR viewport.
 - ◆ Activates this viewport.
10. Right click and select **X Unit > ppm**.
 - ◆ This displays the ppm scale below the spectrum, which designates the chemical address of each metabolite.
11. In the UR viewport change number of pixel to one.
 - ◆ This setting avoids cursor size smoothing.

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Chapter 15

Imaging with ASSET

Introduction

Array Spatial Sensitivity Encoding Technique (ASSET) is an imaging feature that allows faster scanning when using phased array coils. It is designed to achieve shorter breath-held acquisitions, thus making it easier for your patients experiencing difficulty holding their breath for long periods of time.

This chapter explains the characteristics of ASSET. It also explains the step-by-step instructions to help you learn how to:

- Prescribe an ASSET Calibration Sequence
- Prescribe an ASSET Imaging Sequence

In addition, this chapter answers the following questions:

1. What is ASSET?
2. When would you use ASSET?
3. Which imaging options are compatible with the ASSET feature?

What Do I Need to Know About...

This section presents the concepts necessary to successfully understand imaging with ASSET. Specifically, you need to understand:

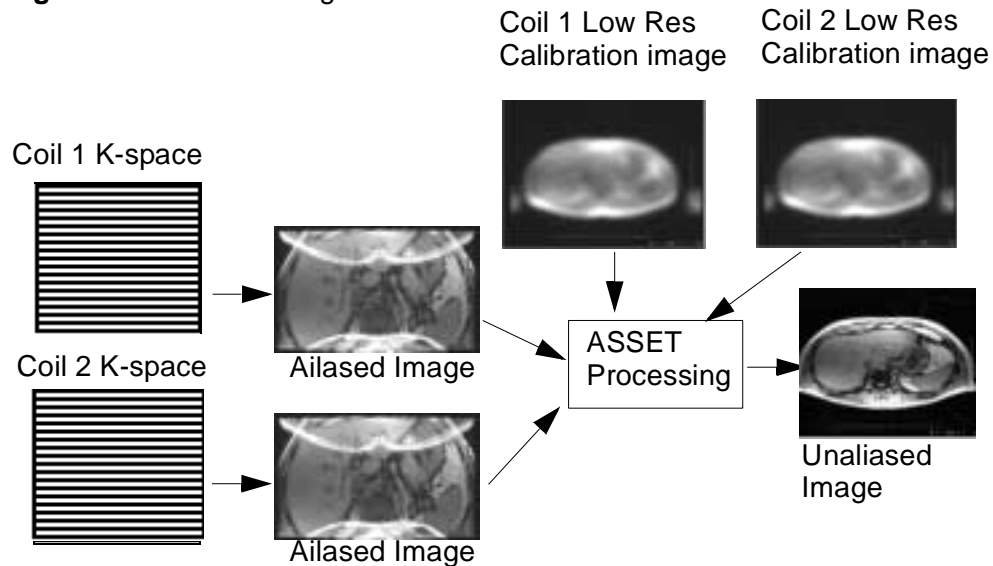
- ASSET Description
- Scan Parameters
- ASSET Characteristics
- Associated Imaging Options
- Applications

ASSET Description

ASSET is a technique for reducing scan time when phased array coils are used. This imaging option is only compatible with Fast Gradient and Fast Time of Flight (TOF) Gradient pulse sequences. The reduction in scan times is due to every other line within K-space being skipped, while keeping the total area covered in K-space the same. A half phase FOV (0.5 PFOV), is an example of a technique that uses a similar principle. ASSET requires a calibration scan prior to the image acquisition. This calibration scan is required because the system needs to account for the phase wrapped or aliased anatomy that occurs within each coil in the phased array set. The calibration scan measures each receive coil's sensitivity (spatial image intensity weighting). These sensitivity maps are needed to unwrap the aliasing in the ASSET scan (Figure 15-1). The calibration acquisition takes approximately six seconds.

The aliasing occurs in an ASSET scan and not in a non-ASSET scan because the ASSET acquisition is, in effect, acquiring half the data in the phase FOV direction. Anytime there is anatomy outside the FOV in the phase direction, aliasing or wrap around occurs.

NOTE: At this time ASSET Imaging is only compatible with the TORSO Phased Array (PA) coil.

Figure 15-1 ASSET Diagram

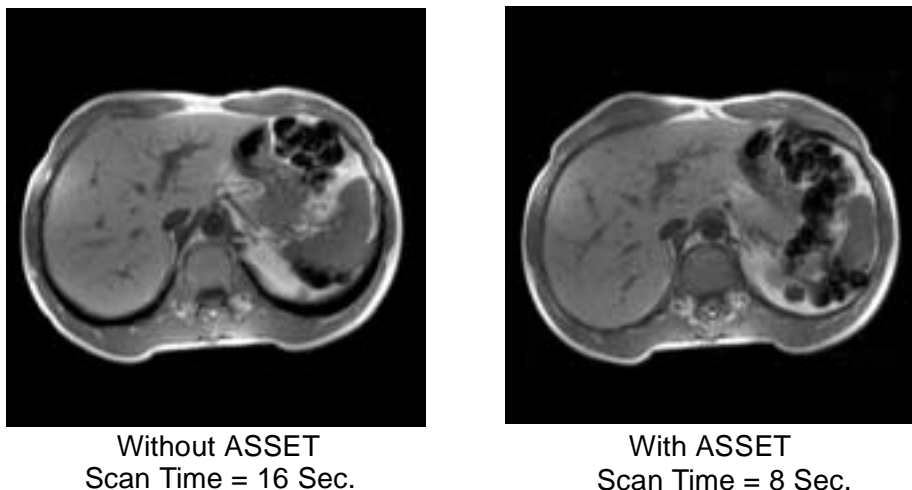
The receive coil sensitivities must be measured in a separate acquisition, called ASSET Calibration before any ASSET image acquisitions are performed. The information obtained during ASSET calibration is stored and used throughout the patient's exam. You only need to perform the ASSET Calibration once for your entire exam. However, you may acquire more, if the scanning ranges change considerably throughout your exam. If more than one calibration is done, the data is used from the most recent calibration scan. Once you have ended the exam the ASSET calibration information is discarded. ASSET Calibration images are saved as a separate series, and can be recalled from the Browser into the viewer.

NOTE: If another exam is performed on the same patient, another ASSET Calibration must be performed.

In Figure 15-2, Fast Gradient Echo (FGRE) images are shown with and without the use of ASSET. Both images were acquired with the same scan parameters, but note the considerable difference in scan times.

NOTE: The scan parameters used in Figure 15-2 were: 2.3 Time to Echo (TE), 62 bandwidth (RBW), 15 slices, 8 mm thick, 2 mm space, 34 FOV, 26 phase FOV, 256x128 matrix with 1 number of excitations (NEX).

Figure 15-2 Conventional FGRE vs. FGRE with ASSET



ASSET can be used with four different pulse sequences.

- 2D Fast Gradient Echo (Fast GRE)
- 2D Fast Spoiled Gradient Echo (Fast SPGR)
- 3D Fast Time of Flight Gradient Echo (Fast TOF GRE)
- 3D Fast Time of Flight Spoiled Gradient Echo (Fast TOF SPGR)

Only 2D Fast GRE and 2D Fast SPGR pulse sequences are compatible with ASSET calibration. After the calibration scan is acquired, any of the four ASSET pulse sequences can use the calibration data to perform the ASSET image acquisitions. ASSET calibration images are annotated “CAL” in the lower left corner of display screen. These images are not clinically diagnostic and are not recommended for filming. Images acquired during ASSET imaging are annotated “AST” in the lower left corner of display screen.

Scan Parameters

Scan parameters most used with ASSET are divided into three sections, Scan Timing parameters, Acquisition Timing parameters and Scanning Range parameters. Selection of these parameters can vary for each acquisition and between ASSET calibration and ASSET imaging acquisitions.

ASSET Calibration

You must select the ASSET Calibration imaging option, located on the Imaging Options window, in order to perform this acquisition. During ASSET calibration several scanning parameters are not selectable. The only

selectable scan parameters are plane, PSD, slice thickness and slice locations. The calibration data must cover the scanning range of the ASSET image acquisition. Therefore, prescribe the ASSET Calibration scanning range from the posterior to the anterior, or the right to left, or inferior to superior borders of the anatomy. ASSET Calibration FOV will be set at 48 cm, and can not be changed.

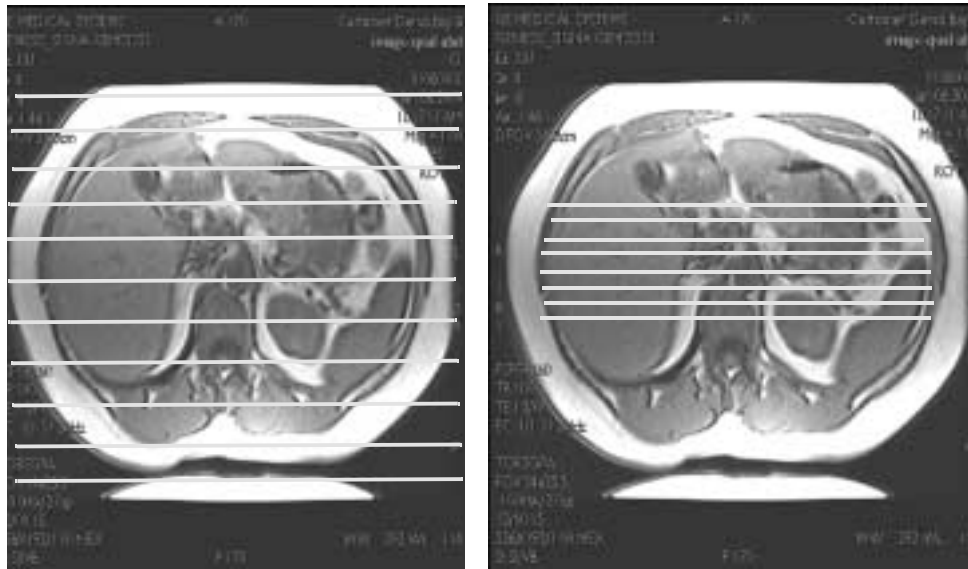
ASSET Imaging

Selection of scanning and acquisition parameters should be chosen to best display your desired imaging anatomy. You must select ASSET on the Imaging Options window in order to perform any acquisition using ASSET.

NOTE: Refer to the Fast Gradient Echo and Fast Time of Flight Pulse Sequences chapters in the Signa® MR/i™ with Signa Select (ASP2)™ guide for additional information on these pulse sequences.

The scanning range of the ASSET image acquisition must be within the borders of the scanning range used for the ASSET Calibration acquisition. Scan regions that fall outside of the calibration volume will be blank in the final images. gives an example of an acceptable scanning range.

Figure 15-3 ASSET Calibration and ASSET Imaging Scanning Range



ASSET Calibration scanning range

ASSET Imaging scanning range

ASSET Characteristics

ASSET images are subject to similar image characteristics as conventional Fast Gradient pulse sequences images. The primary applications for using the ASSET option include:

- Decreased scan time
 - For example, scan time decreases with the use of a smaller phase FOV.
- Increased resolution
 - For example, you can increase the spatial resolution by selecting a larger phase matrix, with the same scan time when compared to images acquired without using ASSET.
- Increased number of slices
 - For example, if your scan time of 15 seconds allows 6 slices, selecting ASSET decreases the scan time. Therefore, increasing the number of slices and moving into a dual acquisition allows more slices within the same 15 second breath hold.

However, everything in Magnetic Resonance Imaging (MRI) has a drawback, ASSETs drawback is the notable decrease in signal to noise ratio (SNR). When comparing two images acquired with and without the ASSET option, the ASSET images will have an SNR loss comparable to halving the NEX (slightly more than a 40% loss). Exams with high signal, such as Contrast Enhanced Magnetic Resonance Angiography (CEMRA) the SNR effects are rarely noticed. Several of the parameter imaging effects are the same as for the Fast Gradient and Fast TOF Gradient pulse sequences. A refresher of such parameters and their imaging effects are listed in Table 15-1. An example of Renal CEMRA 13 second acquisition using ASSET is shown in Figure 15-4.

Figure 15-4 ASSET CEMRA



Table 15-1 Characteristics Table

Parameters	Image Effect			
	Echo Spacing	SNR	Resolution	Scan Time
Gradient Slew Rate ↑	↓	N/A	N/A	N/A
Receive Bandwidth ↑	↓	↓	N/A	N/A

Parameters	Image Effect			
	Echo Spacing	SNR	Resolution	Scan Time
Frequency Matrix ↑	↑	↓	↑	N/A
Phase Matrix ↑	N/A	↓	↑	↑
FOV ↑	↓	↑	↓	N/A
Phase FOV ↑	N/A	↑	N/A	↑
NEX ↑	N/A	↑	N/A	↑

Associated Imaging Options

There are several Imaging Options that can be used in conjunction with ASSET. In Table 15-2 the Xs indicate the options compatible with ASSET.

Table 15-2 ASSET Imaging Options Compatibility Chart

Imaging Options			
	None	X	Variable Bandwidth
X	Flow Compensation		No Phase Wrap
	POMP	X	Extended Dynamic Range
	Square Pixel	X	Surface Coil Intensity Correction
	Respiratory Compensation		Classic
X	Magnetization Transfer	X	Sequential
X	Cardiac Gating/Triggering	X	Respiratory Gating/Triggering
	Tailored RF	X	IR Prepared
X	DE Prepared	X	Multi-Phase
	Full Echo Train		CCOMP
	ZIP 1024	X	ZIP 512
X	Zip x 2	X	ZIP x 4
X	SmartPrep		Blood Suppression
X	Multi Station		Real Time
	T2 Prep		Spectral Spatial RF

Imaging Options			
	Phase Sensitive		Fluoro Trigger
X	ASSET Calibration	X	ASSET

Applications

Currently ASSET is used for body applications. These body applications include abdomen and chest imaging, as well as breath-held angiography studies.

How Do I...

This section provides the step-by-step instructions for performing an ASSET acquisition. Specifically, it describes how to:

- Image with ASSET Acquisitions
 - Prescribe an ASSET Calibration Sequence
 - Prescribe an ASSET Imaging Sequence

In Brief: Perform an ASSET Calibration Sequence

1. Enter the Patient Information.
2. Acquire a valid 3-Plane Localizer series.
3. Click **[New Series]**.
4. Select **Coil > Torso PA**.
5. Select **Plane > Axial**.
6. Select **Mode > 2D**.
7. Select **Grad Mode > Whole**.
8. Select **Pulse Sequence > Fast GRE or Fast SPGR**.
9. Select **Imaging Options > ASSET Calibration**.
10. Enter **Scanning Range Parameters**.
11. Click the **Graphic Rx** Icon.
12. Press **Shift** and click to deposit the starting slice.
13. Click and drag the add handle to increase the number of slices.
14. Click **[Accept]**.
15. Click **[Save Series]**.
16. Click **[Prepare to Scan]**.
17. Click **[Auto Prescan]**.
18. Give your patient breath holding instructions.
19. Click **[Scan]**.

Image with ASSET Acquisitions

Perform an ASSET Calibration Sequence

ASSET calibration sequences must be performed prior to any sequences using the ASSET feature. This sequence acquires the data necessary for effectively performing ASSET imaging.

Use this procedure to set-up and scan an ASSET calibration sequence. These images are not to be used for clinical diagnostic purposes and are not recommended for filming.

1. Enter the Patient Information.
 - ◆ Located on the **Scan Rx Desktop**.
2. Acquire a valid 3-Plane Localizer series.
 - ◆ Make sure the localizer covers the desired anatomy.
3. Click **[New Series]**.
4. Select **Coil > Torso PA**.
 - ◆ ASSET is only compatible with the Torso Phased Array (PA) coil, at this time.
5. Select **Plane > Axial**.
 - ◆ ASSET calibration is compatible with any imaging plane.
6. Select **Mode > 2D**.
 - ◆ ASSET calibration is only compatible with 2D mode.
7. Select **Grad Mode > Whole**.
 - ◆ ASSET Calibration is only compatible with the Whole gradient mode.
8. Select **Pulse Sequence > Fast GRE or Fast SPGR**.
 - ◆ ASSET calibration is only compatible with FGRE and FSPGR.
9. Select **Imaging Options > ASSET Calibration**.
 - ◆ This imaging option must be selected in order to perform this sequence.
 - ◆ This is the only imaging option compatible with ASSET calibration.

10. Enter the **Scanning Range** Parameters.
 - ◆ Choose your location to optimize your desired anatomy coverage.
 - Typically an 8 mm slice thickness provides enough slices within a single acquisition to cover the scanning range from one border of the anatomy to the opposite border of anatomy (left to right, anterior to posterior, or inferior to superior). If not, increase the slice thickness until the prescription is a single acquisition.
11. Click the **Graphic Rx** Icon.
 - ◆ Located in the **Additional Parameters** area.
12. Press **Shift** and click to deposit the starting slice.
13. Click and drag the add handle to increase the number of slices.
 - ◆ Prescribe enough slices to cover from one border of the anatomy to the opposite border of anatomy (left to right, anterior to posterior, or inferior to superior). This insures that you can place your ASSET image prescription anywhere on the localizer and there will be a CAL file available.
 - ◆ Maximum number of slices is 128.
14. Click **[Accept]**.
 - ◆ Registers slice locations into current acquisition.
 - ◆ Location values are displayed in the Scanning Range area.
15. Click **[Save Series]**.
 - ◆ Closes the current prescription screen.
16. Click **[Prepare to Scan]**.
 - ◆ Downloads ASSET calibration acquisition.
17. Click **[Auto Prescan]**.
18. Give your patient breath holding instructions.
 - ◆ Use the same breath hold instructions that will be used in the ASSET Image acquisition.
19. Click **[Scan]**.
 - ◆ Initiates your ASSET calibration acquisition.

In Brief: Perform an ASSET Imaging Sequence

1. Click **[New Series]**.
2. Select **Coil > Torso PA**.
3. Select **Plane > Axial**.
4. Select **Mode > 2D** or **3D**.
5. Select **Grad Mode > Whole**.
6. Select **Pulse Sequence > any Fast Gradient Echo pulse sequence**.
7. Select **Imaging Options > ASSET**.
8. Enter in all imaging parameters.
9. Click the **Graphic Rx** icon.
10. Press **Shift** and click to deposit the starting slice.
11. Click and drag the add handle to increase the number of slices.
12. Click **[Accept]**.
13. Click **[Save Series]**.
14. Click **[Prepare to Scan]**.
15. Click **[Auto Prescan]**.
16. Give your patient breath holding instructions.
17. Click **[Scan]**.

Image with ASSET Acquisitions

Perform an ASSET Imaging Sequence

ASSET is an imaging technique that is used for rapid breath held scanning. A couple specific applications are rapid liver imaging and contrast enhanced renal MRA studies.

Use this procedure to set-up and scan an ASSET imaging sequence. ASSET imaging sequences are only to be performed proceeding an ASSET calibration acquisition.

1. Click **[New Series]**.
2. Select **Coil > Torso PA**.
 - ◆ ASSET is only compatible with the Torso PA coil.
3. Select **Plane > Axial**.
 - ◆ ASSET imaging is compatible with any imaging plane.
4. Select **Mode > 2D** or **3D**.
 - ◆ ASSET imaging is only compatible with 2D and 3D modes.
5. Select **Grad Mode > Whole**.
 - ◆ ASSET is only compatible with both gradient modes.
6. Select **Pulse Sequence > any Fast Gradient Echo pulse sequence**.
 - ◆ ASSET imaging is only compatible with Fast Gradient pulse sequences.
 - Fast GRE and SPGR sequences are recommended for abdominal imaging.
 - Fast TOF GRE and SPGR sequences are recommended for angiography imaging.
7. Select **Imaging Options > ASSET**.
 - ◆ You must select this imaging option in order to perform an ASSET acquisition.
8. Enter in all imaging parameters.
 - ◆ Parameters should reflect the specific protocol tailored to the current imaging exam.
 - ◆ For specific exam protocols refer to either your site tailored protocols or GE pre-loaded protocols.

9. Click the **Graphic Rx** Icon.
 - ◆ Located in the **Additional Parameters** area.
18. Press **Shift** and click to deposit the starting slice.
10. Click and drag the add handle to increase the number of slices.
 - ◆ Slice locations should match or be within the imaging range of the ASSET calibration series.
 - ◆ Maximum number of slices is 128.
11. Click **[Accept]**.
 - ◆ Registers slice locations into current acquisition.
 - ◆ Location values are displayed in the Scanning Range area.
12. Click **[Save Series]**.
 - ◆ Closes the current prescription screen.
13. Click **[Prepare to Scan]**.
 - ◆ Downloads ASSET imaging acquisition.
14. Click **[Auto Prescan]**.
15. Give your patient breath holding instructions.
 - ◆ Use the same breath hold instructions that will be used in the ASSET Image acquisition.
16. Click **[Scan]**.
 - ◆ Initiates your ASSET imaging acquisition.

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Appendix

MR Compatibility Test Guidelines for the Signa System

Scope and Summary

Introduction

The document describes a set of procedures and standards which can be used to evaluate the “MR Compatibility” of hand-held, non-electronic equipment used in conjunction with the Signa system.

Included are a definition of MR Compatibility, a scheme for classification of equipment, and a set of tests and standards for assessing MR Compatibility.

A Working Definition of MR Compatibility

For the purposes of this document, “MR Compatibility” shall be defined as follows:

- A device shall be considered MR Compatible if and only if:
 - It’s presence in the Signa magnet room does not pose an increased safety risk to the patient or other personnel [MR Safety]
 - It performs its intended function when used in conjunction with the Signa system in a safe and effective manner [Device Safety and Effectiveness]
 - Its use in conjunction with the Signa scanner does not adversely impact the function of the scanner [Scanner Compatibility]

A device may be MR Compatible for certain types of use but not for others. The idea of “usage classification is discussed. Note that MR Compatibility does not imply general safety. Other normal operating room safety issues (sterility, electrical isolation, etc.) must be addressed independently of MR Compatibility.

The components of the definition of MR Compatibility are discussed below.

MR Safety

The “MR Safety” part of the definition is related to whether the presence of the device in question in or near the Signa system poses an additional safety risk. The primary areas of concern are:

- Magnet forces: The device must not be attracted to the magnet with sufficient force as to be a projectile. The device must not experience sufficient torque as to be a possible source of injury.
- Heating: The device or immediately surrounding tissue must not have the potential to become hot enough to cause injury during scanning.

Device Safety and Effectiveness

“Device Safety and Effectiveness” refers to whether the introduction of the device into the Signa environment alters the way in which the device functions. In order to be MR compatible, the device must perform its intended function effectively and in a way that does not pose a safety risk while in the Signa SP scanner environment.

NOTE: GE shall not be responsible for assessing the proper function of any device. The manufacturer of the device must make arrangements to test their device in the MRI environment. Written certification that the device functions as intended in the MRI environment shall be provided before the device shall be considered MR compatible.

The following are aspects of the MRI environment which may impact device function:

- Large static magnetic field
- Rapidly changing magnetic field
- Radio frequency energy

Scanner Compatibility

Scanner compatibility refers to whether the use of the device in conjunction with the scanner adversely affects scanner performance (signal to noise ratio, artifacts, image distortion, etc.). The areas of concern are:

- **Static Magnetic Field Homogeneity:** The device must not cause significant changes in the main magnetic field homogeneity.
- **Radio Frequency Interference:** The device must not distort the transmit pattern of the RF energy used for imaging. The device must not generate significant radio frequency (RF) energy in the sensitive range of the scanner.

Classification

This document applies to hand-held, non-electronic devices. The degree of MR Compatibility required for a device is broken into four “zones” according to where the device will be used during scanning. Knowledge of the correct MR Compatibility Zone allows the appropriate MR Compatibility tests and standards for the device in question to be determined.

Testing Approach

The tests used to assess MR compatibility fall into the following areas:

- Magnet Forces and Torques
- Heating
- Magnet Field Distortion (Static)

Each area has tests and acceptance criteria appropriate to the MR Compatibility Zones.

When a new device is considered for MR Compatibility, it is first classified. Then the appropriate tests and acceptance criteria are chosen. Once the device passes the tests, and the device manufacturer has provided in writing the results of their functionality tests indicating that the device functions as intended in the MR environment, the device may be designated “MR Compatible” for the Zone tested. The tests are designed such that MR Safety is independent of the Zone tested. For example, a Zone 4 hand-held device may be safely positioned at iso-center and scanned but may cause severe image distortions and/or artifacts.

Results of MR Compatibility testing should be maintained on file at the site along with design drawings and any other documentation necessary to describe the device. Since design changes may make the device incompatible, any changes must be reviewed with and approved by the site testing personnel in order to maintain the “MR Compatibility” of the device. Some changes may necessitate retesting.

Applicable Documents

MR Compatibility Test Specifications

- Magnet Forces and Torques Test Specification
- Heating Test Specification
- Magnet Field Distortion (Static) Test Specification

Classifications

In order to manage the tremendous variety of devices and applications, the following classifications are used throughout this document.

Device Classifications

The tests specified assume the device has the following properties:

- Electrically Passive: The device contains no electric or electronic circuitry.
- Hand-Held: The device can be comfortably lifted and manipulated with one hand by a typical person. Such devices typically will weigh less than 2kg.

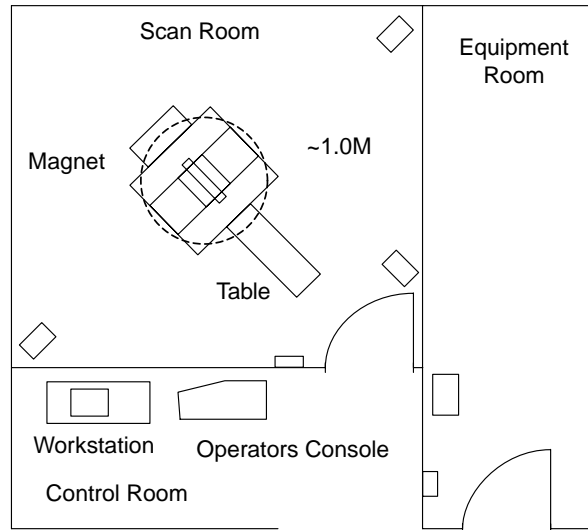
Usage Classifications

The degree of MR compatibility required depends on the intended use of the device. The degree of MR compatibility shall be designated Zone 1, 2, 3, or 4:

- A device which is Zone 1 MR Compatible is suitable for use in the imaging volume, potentially in contact with the patient, during scanning.
- A device which is Zone 2 MR Compatible is suitable for use in the imaging volume, potentially in contact with the patient, during scanning, provided that the device is at least 5cm away from any anatomical feature for which spatially accurate images are required.
- A device which is Zone 3 MR Compatible is suitable for use in the imaging volume, potentially in contact with the patient, when not scanning. The device should be moved outside of 1.0 m from iso-center during scanning.
- A device which is Zone 4 MR Compatible is suitable for use in the scan room during scanning when kept more than 1.0m from iso-center.

The highest Zone of MR Compatibility is Zone 1. A Zone 1 MR compatible device may be used in the imaging volume in the region of interest without degradation of image quality or spatial accuracy. Biopsy needles and endoscopes would typically be Zone 1 devices. A Zone 2 device may be used in the imaging volume but can cause spatial distortions and artifacts nearby (within 5cm). Typical Zone 2 devices would include positioners and microscopes. A Zone 3 device should be removed from the scan volume prior to scanning to avoid spatial distortion and artifacts. The majority of MR Compatible hand-held surgical instruments would be Zone 3 devices. A Zone 4 MR compatible device should not cause problems only if it is no closer than 1.0m from iso-center. Typical Zone 4 devices include furniture and carts. Note that the same type of device can be made MR Compatible to any Zone depending on the material used in fabrication. For example, a scalpel can be either Zone 1, 2, or 3. A scalpel made of a non-ferrous metal might be Zone 3 MR Compatible, while one made of ceramic could be Zone 1 MR Compatible.

A diagram of a typical suite appears in the following diagram.



Test Descriptions

This section describes in general terms the tests used to assess MR Compatibility. Please see the referenced test procedures for detailed test descriptions. The tests used to assess MR compatibility fall into the following areas:

- Magnet Forces and Torques
- Heating
- Magnet Field Distortion (Static)

Magnet Forces and Torques

The following are general descriptions of the tests used for magnet forces and torques. Please see document “MR Compatibility Tests: Magnet Forces and Torques Test Specification” for a complete description.

MFT Test 1: Screening

Part A

This test is to be performed outside of the screen room. A hand magnet is suspended on a string and the device is slowly brought into contact with the magnet. If the hand magnet is strongly attracted to the device, the test fails. See “MR Compatibility Guidelines: Magnet Forces and Torques Test Specification” for details.

Results: Pass/Fail

Part B

This test is to be performed using the Signa magnet. Only devices which have passed the screening test should be tested. The following apparatus is required: clear plastic box with locking lid, paper, marking pen.

The device is placed in a clear box on top of a sheet of paper, its outline is traced on the paper and the lid closed and locked. The device is then moved into the magnet bore and then removed from the bore. If the device moves or pivots as it moves into or out of the bore, it fails. The test is repeated with the device oriented 90 degrees from its original position.

Results: Pass/Fail

MFT Test 2: Small Object Test

This test is to be performed using the Signa magnet ramped. Only devices which have passed the screening test should be tested. The following apparatus is required: deflection meter.

The device is suspended from a string and slowly carried toward the Signa magnet until it is positioned in a known magnetic force area. The angle of deflection of the string (and thus the force on the device) is monitored.

Results: Pass/Fail

Heating

The following is a general description of the Heating test. Please see document "MR Compatibility Guidelines: Heating Test Specification" for a complete description. The tests are applicable only for devices which can physically be located inside of a 1.0m diameter sphere centered at iso-center during scanning. Other devices may be exempted.

Heating 1: Heating Test 1

This test is used for devices which may be in surface contact with the patient or operator during scanning and for devices which may be inserted into the patient during scanning. This test is to be performed using the Signa magnet ramped.

Use one of the conductive gel samples specifically designed for the heating test. Paint the exposed surfaces of the device with the temperature sensitive paint. The paint is water-based and undergoes a permanent change if its temperature exceeds a specific value. Position the device next to or in the gel as it would be positioned in the skin. Run the Heating Test PSD listed under the GE Protocols on the system. Remove the device from the scanner after the scan is complete and examine the device to determine if any surfaces exceeded the prescribed temperature. If any surfaces exceeded the appropriate temperature threshold the device fails.

Results: Pass/Fail

Magnet Field Distortion

The following are general descriptions of the Magnetic Field Distortion tests. Please see document "MR Compatibility Guidelines: Magnetic Field Distortion Test Specification" for a complete description.

MFD Test 1: Local Field Disturbance

This test is to be performed using the Signa magnet ramped. Only devices which have passed the magnet forces test should be tested. Zone 3 and Zone 4 devices do not need to be tested.

This test is designed to evaluate local field disturbances from devices that would be in the imaging volume during scanning. A copper sulfate phantom is scanned, then the device is submerged in the solution and the phantom is re-scanned. The change in field due to the device is measured and the potential impacts on signal intensity and spatial accuracy are reported.

Results: Zone 1: Pass/Fail
Zone 2: Pass/Fail

Test Procedure

The following procedure shall be used to assess whether a device is “MR Compatible”.

1. Make sure that all the appropriate documentation has been provided: the documentation shall include a detailed mechanical drawing indicating the types of materials used in fabrication.
2. Determine the appropriate device and usage classifications.
3. Perform the magnetic force screening test. If the device passes, go on to step 4. If not, the device shall not be designated “MR Compatible”.
4. Confirm that the manufacturer performed a test of the device functionality in the Signa system and/or provides satisfactory documentation indicating that the safe function of the device is not compromised by its introduction into the MR environment.
5. Determine the appropriate tests for the device.
6. Perform the indicated tests and record the results. If all the test results are within the acceptance criteria, the device may be considered “MR Compatible” to the lowest Zone passed.

The results of the MR Compatibility test shall be recorded on the MR Compatibility data sheet.

Please reference the indicated sections for test descriptions.

Table 1: Compatibility Test Selection

	<u>Magnetic Force</u>	<u>Heating</u>	<u>Field Distortion</u>
Zone 4	4.1.2	4.2.1	n/a
Zone 3	4.1.2	4.2.1	n/a
Zone 2	4.1.2	4.2.1	4.3.1
Zone 1	4.1.2	4.2.1	4.3.1

Table 2: Compatibility Test Acceptance Criteria

	<u>Magnetic Force</u>	<u>Heating</u>	<u>Field Distortion</u>
Zone 4	<30° deflection	<5°C	n/a
Zone 3	<30° deflection	<5°C	n/a
Zone 2	<30° deflection	<5°C	<100 counts above zero distortion (at 5cm)
Zone 1	<30° deflection	<5° C	<100 counts above zero distortion

MR Compatibility Data Sheet

Device Information

Device Name: _____ Model #: _____
 Manufacturer: _____ Serial #: _____
 Description: _____

Documentation Checklist:

- A set of detailed mechanical drawings indicating the type of material used (attach copy)
- Results of Manufacturer test indicating the device functions as intended in the MRI environment (attach copy)

Device Classification:

Circle One: Handheld portable stationary
 Circle One: electrically active electrically passive
 MR Compatibility Zone Required (circle one)

1 2 3 4

Results of Magnetic Forces Screening Test: Pass Fail

Comments (if failed): _____

List the required tests from Table 1 along with test results:

Test	Results	Status (circle lowest Zone passed)				
_____	_____	4	3	2	1	none
_____	_____	4	3	2	1	none
_____	_____	4	3	2	1	none
_____	_____	4	3	2	1	none
_____	_____	4	3	2	1	none
_____	_____	4	3	2	1	none
		_____	_____	_____	_____	_____
	Overall Status (circle highest of above)	4	3	2	1	none

Magnetic Forces and Torques Test Specification

Scope and Summary

Introduction

This document describes the Magnetic Forces and Torques (MFT) Test Specification called out in the “MR Compatibility Test Guidelines for the Signa System.” Three tests are described:

- MFT 1: Screening
- MFT 2: Small Object Test
- MFT 3: Small Object Test

The MFT Screening Test Part A (MFT 1A) is designed to exclude devices which may be strongly attracted to the Signa magnet. The results of the MFT Screening Test Part A shall be either “Pass” or “Fail”. The MFT Screening Test Part A shall be performed prior to the introduction of any device under consideration for the MR Compatibility into the magnet room. The MFT Screening Test Part B (MFT 1B) is designed to pass devices which experience no force or torque while in the Signa SP magnet. The MFT Screening Test Part B involves moving the device into and out of the magnet and detecting any translation or rotation of the device. The results of the MFT Screening Test Part A shall be either “pass” or “fail”.

The MFT Small Object Test 2 (MFT 2) shall be used for devices which have passed the screening test (MFT 1). The test involves moving the device toward the magnet in a controlled fashion while the force on the device is monitored.

Applicable Documents

MR Compatibility Test Guidelines for the Signa System

Test Equipment

The MFT Screening Test Part A requires the use of a hand-held permanent magnet. The magnet used shall be an Edmund Scientific 25 lb. pull SN #40847 or equivalent.

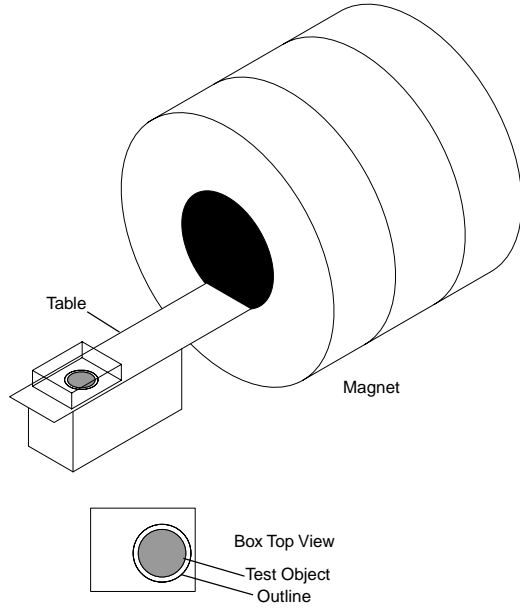
The MFT Screening Test Part B and the MFT Small Object Test 2 require the use of the Signa magnet. The following apparatus is required:

- MFT Screening Test — Part B
 - Clear Plastic box with locking lid
 - Plastic box-sized sheets of paper
 - Marking pen
- MFT Small Object — Test 2
 - Deflection meter (level - equipped protractor with a string attached)
 - Mesh bag

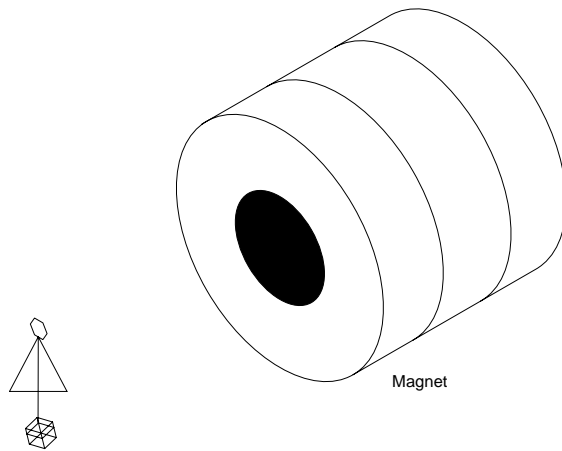
Test Procedures

Small Object Test 1: Screening Test

Part A



Apparatus of MFT Screening Test Part B



Apparatus of MFT

The MFT Screening Test Part A shall be performed outside the screen room. Suspend a hand magnet (Edmund Scientific 25 lb. pull SN#40847 or equivalent) with a string (as opposed to a metallic wire). Slowly bring the device into contact with the magnet. If the magnet moves and the string deflects from vertical before the device touches the magnet, or if the device sticks to the magnet and pulls the magnet so that the string deflects from vertical, the device fails.

Results: Pass/Fail.

Part B

The MFT Screening Test Part B is designed to detect any magnetic force or torque on a device. Only devices which have passed the Magnetic Forces and Torques Screening Test Part A should be tested.

The MFT Screening Test Part B uses the setup shown in Figure 2. While outside the procedure room, place the device to be tested into the plexiglass box on top of a piece of paper which has been taped into the bottom of the box. Draw an outline of the device on the paper to indicate its initial position. Close and secure the lid. Place the box on the outer end of the patient table and secure it to the table. Make sure that the device has not shifted. Move the table such that the box with the device is moved to magnet iso-center, then return it to the starting position. If the position of the device relative to its outline has not changed (including rotation), the device passes. Repeat the test with the device oriented 90 degrees from its original position.

Results: Pass/Fail

Small Object Test 2

The Magnetic Forces and Torques Small Object Test 2 is designed to determine the magnetic force and torque on a device. Only devices which have passed the Magnetic Forces and Torques Screening Test (MFT 1) should be tested.

The Magnetic Forces and Torques Small Object Test 2 uses the setup shown in Figure 1. While outside the procedure room, place the device to be tested into a mesh bag. Adjust the position of the device in the bag such that its long axis is parallel to the floor. Run the string attached to the mesh bag through the center hole of the deflection meter.

Hold the deflection meter level, out in front of you and pointing at the magnet as you enter the procedure room. Walk slowly toward the magnet while observing the angle of deflection. Make sure to keep the device between yourself and the magnet. If the angel of deflection exceeds 30°, stop the test and remove the device from the procedure room. Otherwise, continue moving toward the patient end of the magnet until the top center of the deflection meter touches the top of the magnet opening at the patient end. Align the deflection meter with the Z axis of the magnet. Record the maximum deflection on the data sheet. If the deflection angle exceeds 30° the device fails.

Results: Pass/Fail

Heating Test Specification

Scope and Summary

Introduction

This document describes the Heating Test Specification called out in the “MR Compatibility Test Guidelines for the Signa System.”

The Heating Test is designed to detect if the device interacts with the Signa system so as to create hazardous temperatures when positioned in the patient or when in contact with the patient's or operator's skin. The maximum safe internal temperature is 41°C, which represents a 4°C rise from normal internal temperature of 37°C. The maximum skin exposure temperature allowed is also 41°C. Skin temperature can reach 37°C during MR scanning, so a temperature increase of 5°C would exceed the allowed temperature. Thus, the temperature level to be detected by the heating test is 28°C, which represents a 5°C rise above normal room temperature of 23°C.

Applicable Documents

MR Compatibility Test Guidelines for the Signa System

Test Equipment

The Signa Heating Test requires the use of a temperature sensitive marking material such as Omega OMEGASTIK Temperature Indicating Crayons or OMEGALAQ Temperature Indicating Lacquer. These materials melt at a specific temperature and maintain an altered appearance when cooled. The specific model used should melt at a temperature of 28°C, assuming a room temperature of 23°C.

The Signa Heating Test also requires the use of a tissue-simulating material. A gel phantom designed to simulate the electrical conductivity properties of tissue has been developed. The gel consists of 9.70% TX-150 (Oil Center Research, Lafayette LA), 9.06% aluminum powder (JT Baker Chemical Co., Phillipsburg, NJ), 80.97% water and 0.27% NaCl.

Test Procedure

Part 1 of the test can be performed outside the procedure room. Part 2 of the test is to be performed in the Signa magnet. Only devices which have passed the required magnet forces and torques test should be tested.

Part 1: Pre-Test Inspection

Before testing the device, inspect it for the following:

- Construction material
 - If the device is constructed entirely of a non-conductive material such as ceramic or plastic (as indicated in information supplied by manufacturer and confirmed by inspection) it may be exempted from further Heating testing.

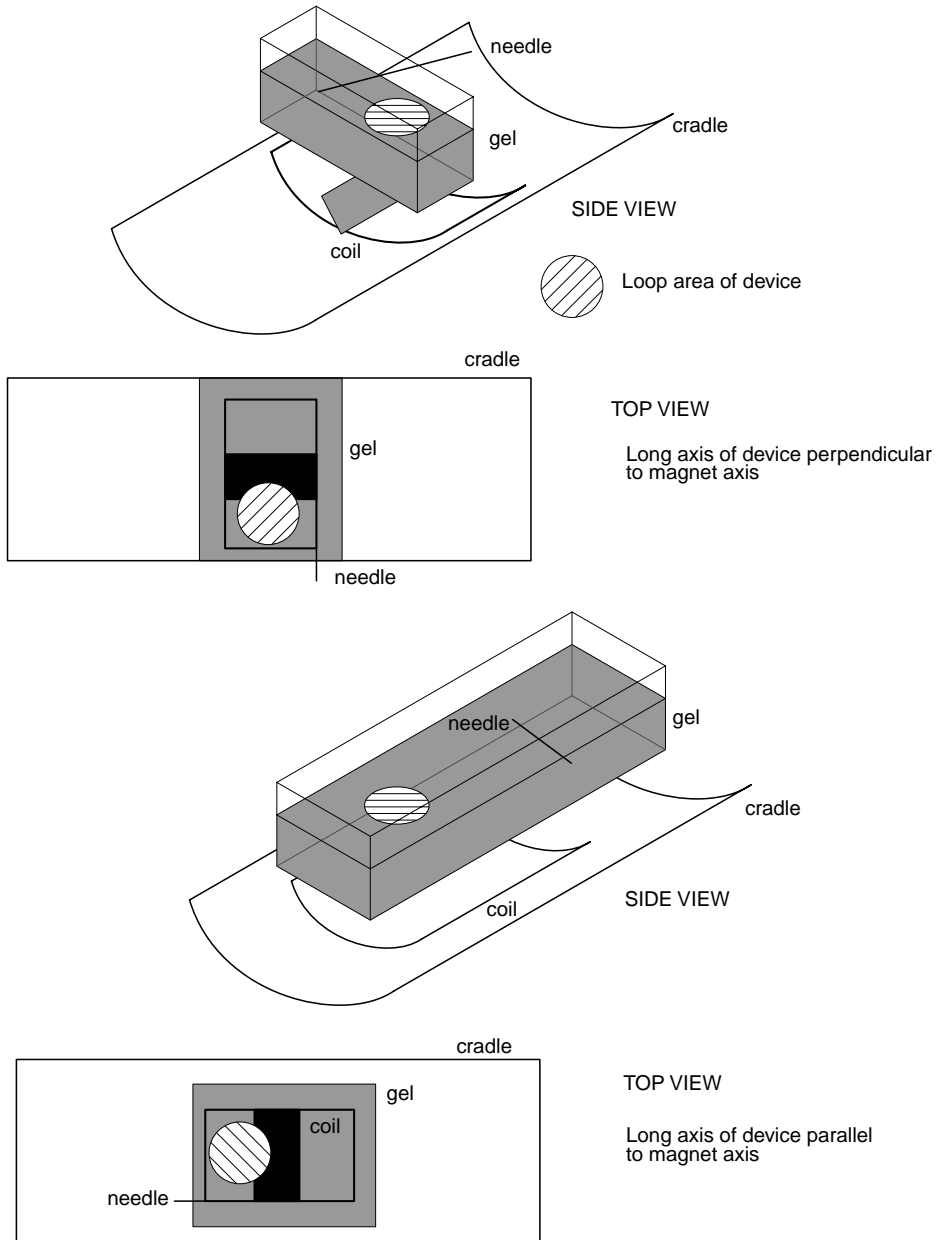
Part 2: Scanner Testing

Apply the temperature indicating material to the surfaces of the device to be tested. Lay the body-flex coil flat on the table at iso-center. Position the device in the tissue simulating gel in a manner that duplicates the relative position between the device and tissue. Place the gel/device on top of one of the sides of the body-flex coil with the long axis of the device aligned perpendicular to the magnet's Z axis. Refer to Figure 1 for recommended coil/device configurations. Scan the device with the Heating Test protocol listed under the GE protocols. The Heating Test protocol exposes the device to the maximum RF power possible on the system for a period of 15 minutes. Observe the device via the over-patient camera during the scan. If you can visually verify that the temperature sensitive material is undergoing a color change you can stop the scan before it's completion to prevent damage to the device. If no change is detectable during the scan, wait for the scan to finish, then remove the device and inspect for temperatures exceeding the melting point of the indicating material. If the indicating material melted at any point on the device, the test fails.

Repeat with the long axis of the device aligned parallel to the magnet's Z axis. If the indicating material melted at any point on the device, the test fails.

If the device has some loop area, repeat the test with the loop area perpendicular to the magnet's Z axis. Refer to Figure for recommended coil/device configurations. If the indicating material melted at any point on the device, the test fails.

A needle is shown in the figures for demonstration purposes. The needle axis represents the long axis on the device being tested.



Distance From Instrument	Instrument Description (MFG, SN#, ETC)						Date _____	
	Plane	Max	Min	Max Deviation from Zero	Max	Min	Max Deviation from Zero	Pass/Fail

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