

Imaging protocols for navigated procedures

How to use this document

This document contains imaging protocols for navigated cranial, DBS and stereotactic, ENT, and spine procedures as well as instructions for placing skin fiducial markers. Work from left to right in the following table to determine which imaging protocol to use and to locate that protocol within this document.

Anatomy	Procedures	Software in which the scans can be used	Protocol	Location in document
Cranial	Tumor resection, shunt placement, and biopsy procedures without a stereotactic frame	Synergy® Cranial Cranial Classic (MACH) PoleStar Navigation	Cranial A	Page 3
		Synergy® Cranial (This protocol does not apply if you are using Synergy® Cranial software version 2.2.x or earlier.)	Cranial B	Page 6
	DBS and stereotactic procedures	FrameLink™ StimPilot®	Cranial C	Page 12
		Synergy® Cranial (This protocol does not apply if you are using Synergy® Cranial software version 2.2.x or earlier.)	Cranial D	Page 16
ENT	Anterior skull base and sinus procedures	Fusion® ENT LandmarX® elemENT LandmarX® eNV®	ENT	Page 20
Spine	All navigated spine procedures	Synergy® Spine Synergy® Spine and Trauma Spine 3D Synergy® Experience TLIF Procedure Solution	Spine	Page 23

If your site is using software that is not listed in the table, contact Medtronic Navigation to obtain the imaging protocol that applies to your software.

The most common scan protocols are highlighted in blue. If you have questions about which protocol to use, contact your local Medtronic Navigation Clinical Specialist or call technical support at +1 800 595 9709 or +1 720 890 3160.

Use the following tables to record the software versions installed on each navigation system at your site.

Medtronic Navigation system name	
Cranial software version	
FrameLink™ software version	
ENT software version	
Spine software version	
Date	

Medtronic Navigation system name	
Cranial software version	
FrameLink™ software version	
ENT software version	
Spine software version	
Date	

Medtronic Navigation system name	
Cranial software version	
FrameLink™ software version	
ENT software version	
Spine software version	
Date	

Cranial A protocol

These requirements apply to scans that will be used in the following software:

Procedures	Software in which the scans can be used
Procedures without a stereotactic frame • Tumor resection • Shunt placement • Biopsy	• Synergy® Cranial • Cranial Classic (MACH) • PoleStar Navigation

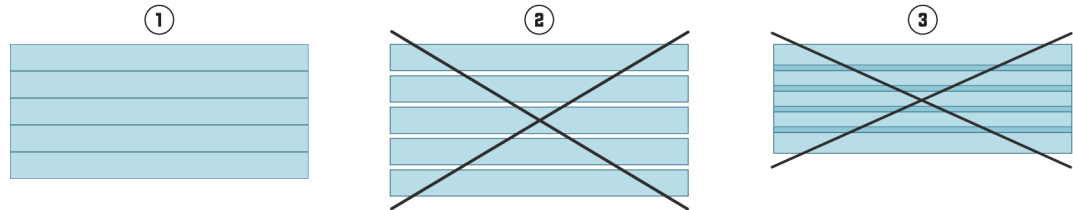
Note: If you are using skin fiducial markers, follow the instructions for “Fiducial marker placement for cranial scans” on page 9.

Cranial A scan requirements

Contrast Contrast agents may be injected before scanning.

Slices

- Scan contiguous slices. (Slice spacing must equal slice thickness. Make sure that there is no gap between slices.)



- ① Correct: contiguous slices with no gap and no overlap
- ② Incorrect: gap between slices
- ③ Incorrect: overlap of slices
- Use a constant slice thickness.
- Use a slice thickness of 1 mm or less, which usually produces the highest quality data set for surgical planning and navigation.
 - Any fractional slice thickness up to 3 mm is acceptable. However, as slice thickness increases, surgical planning and navigation performance can be impacted.
 - 3 mm is the largest slice thickness acceptable for cranial scans.
- Axial slices are preferred.

Size and pixels

- Use a square image matrix of 256 x 256 pixels or 512 x 512 pixels.
- Use square pixels.

Cranial A CT scans only

- Use a standard soft tissue algorithm.
- Do not use gantry tilt.
- Axial/helical scans are acceptable using a pitch ratio of 1:1. If you use helical scans, make sure that you do not see image artifacts in the reconstructed image slices.
- Use a circular (or square) field of view (FOV). Use the smallest FOV to encompass the region of interest, which is usually up to 25 cm (250 mm).

Include the top of the head, the skull base, and the nose. If the scan will be merged with other scans using StealthMerge® software, make sure that there is an air gap around the head.

Cranial A MR scans only

- Do not use oblique slices. Scan along the axis of the magnet bore.
- Use single-echo scans. Do not use multi-echo scans.
- Any MR imaging sequence can be used to show anatomy/pathology. However, if the scans will be merged, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, and MRA have not been evaluated. Scans taken in the same Frame Of Reference as the MR-T1, MR-T2, MR-PD, or FLAIR may still be used if merged with Identity Merge.
- MR 3D volume acquisition is acceptable as long as the scan can be reconstructed in a way that conforms to all requirements of the imaging protocol.

Scans to merge

If you intend to merge two or more exams using StealthMerge® software, ensure that multiple identifiable landmarks and the skull base are included in all of the scans to enable matching.

CT, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, MEG, CTA, and MRA have not been evaluated.

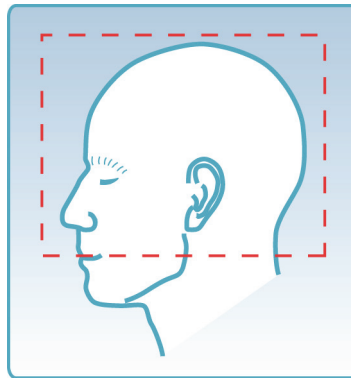
If you intend to merge O-arm® exams with preoperative exams, you may use any imaging mode, except when using an O-arm® O-1000 system. For O-arm® O-1000 systems, use the high definition 3D or enhanced cranial 3D modes.

Scan region

Scan from the superior aspect of the horizontal portion of the mandible through the top or vertex of the cranium. Include an air gap above the superior aspect of the head. Include all fiducial markers, the ears, maxillary teeth, and the tip of the nose.

Ensure that the tip of the patient's nose is included in the scan and that it is the most anterior point on the scan. Also, start the scan above any dental work to avoid creating artifacts.

This image shows the typical scan region for cranial scans (unless the lesion is very low).



Patient position

Separate the patient's head from the scanner headrest with towels or foam.

Use padding to prevent patient motion, but make sure that the padding does not distort the fiducial markers or the skin.

Make sure that the patient's ears do not touch the sides of the headrest, and that they are not pushed away from their normal position.

Archive format

Archive the scan in an uncompressed file format.

Cranial A scan examination

The surgeon or imaging technologist should examine the completed scan to verify the following quality criteria:

- The patient image orientation is correct.
- The total pathology/region of interest is visible.
- The planned surgical target and entry points are visible.
- The tip of the patient's nose is included in the scan and should be the most anterior point on the scan. Having the tip of the patient's nose as the most anterior point on the scan is preferred for the Tracer® registration method.
- The slice thickness is constant throughout the scan.
- No motion artifact is present. Rapidly scroll through the images to make sure they all line up.
- Be aware of phase encoding (ghost) artifacts. If necessary, work with radiology to reduce artifacts.
- The fiducial markers are clearly visible and are not distorted.
- No gantry tilt was used.
- All other aspects of the imaging protocol were followed.

Cranial B protocol

Procedures	Software in which the scans can be used
Procedures without a stereotactic frame • Tumor resection • Shunt placement • Biopsy	Synergy® Cranial (This protocol does not apply if you are using Synergy® Cranial software version 2.2.x or earlier.)

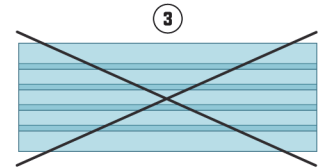
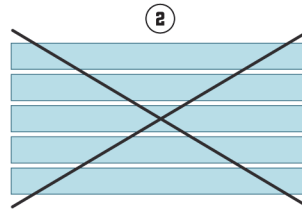
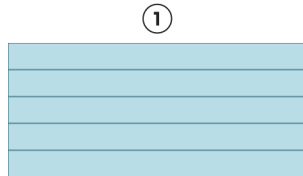
Note: If you are using skin fiducial markers, follow the instructions for “Fiducial marker placement for cranial scans” on page 9.

Cranial B scan requirements

Contrast Contrast agents may be injected before scanning.

Slices

- Scan contiguous slices. (Slice spacing must equal slice thickness. Make sure that there is no gap between slices.)



- ① Correct: contiguous slices with no gap and no overlap
- ② Incorrect: gap between slices
- ③ Incorrect: overlap of slices
- Use a constant slice thickness.
- Use a slice thickness of 1 mm or less, which usually produces the highest quality data set for surgical planning and navigation.
 - Any fractional slice thickness up to 3 mm is acceptable. However, as slice thickness increases, surgical planning and navigation performance can be impacted.
 - 3 mm is the largest slice thickness acceptable for cranial scans.
- Axial slices are preferred.

Size

Use a square or rectangular image matrix of up to 1024 x 1024 pixels.

Note: Scans that are larger than 512 x 512 pixels cannot be used in Synergy® Cranial software version 2.2.x or earlier.

Cranial B CT scans only

- Use a standard soft tissue algorithm.
 - Do not use gantry tilt.
 - Axial/helical scans are acceptable using a pitch ratio of 1:1. If you use helical scans, make sure that you do not see image artifacts in the reconstructed image slices.
 - Use a circular (or square) field of view (FOV). Use the smallest FOV to encompass the region of interest, which is usually up to 25 cm (250 mm).
- Include the top of the head, the skull base, and the nose. If the scan will be merged with other scans using StealthMerge® software, make sure that there is an air gap around the head.

Cranial B MR scans only

- Do not use oblique slices. Scan along the axis of the magnet bore.
- Use single-echo scans. Do not use multi-echo scans.
- Any MR imaging sequence can be used to show anatomy/pathology. However, if the scans will be merged, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, and MRA have not been evaluated. Scans taken in the same Frame Of Reference as the MR-T1, MR-T2, MR-PD, or FLAIR may still be used if merged with Identity Merge.
- MR 3D volume acquisition is acceptable as long as the scan can be reconstructed in a way that conforms to all requirements of the imaging protocol.

Scans to merge

If you intend to merge two or more exams using StealthMerge® software, ensure that multiple identifiable landmarks and the skull base are included in all of the scans to enable matching.

CT, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, MEG, CTA, and MRA have not been evaluated.

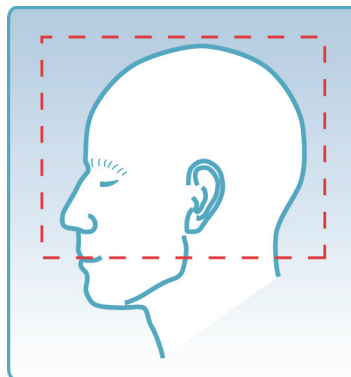
If you intend to merge O-arm® exams with preoperative exams, you may use any imaging mode, except when using an O-arm® O-1000 system. For O-arm® O-1000 systems, use the high definition 3D or enhanced cranial 3D modes.

Scan region

Scan from the superior aspect of the horizontal portion of the mandible through the top or vertex of the cranium. Include an air gap above the superior aspect of the head. Include all fiducial markers, the ears, maxillary teeth, and the tip of the nose.

Ensure that the tip of the patient's nose is included in the scan and that it is the most anterior point on the scan. Also, start the scan above any dental work to avoid creating artifacts.

This image shows the typical scan region for cranial scans (unless the lesion is very low).



Patient position	Separate the patient's head from the scanner headrest with towels or foam. Use padding to prevent patient motion, but make sure that the padding does not distort the fiducial markers or the skin. Make sure that the patient's ears do not touch the sides of the headrest, and that they are not pushed away from their normal position.
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Archive format	Archiving the scan in an uncompressed file format is preferred. If you compress the scan, use a lossless compression method, such as, JPEG lossless or JPEG2000 lossless. Note: Compressed scans cannot be used in Synergy® Cranial software version 2.2.x or earlier.
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Cranial B scan examination

The surgeon or imaging technologist should examine the completed scan to verify the following quality criteria:

- The patient image orientation is correct.
- The total pathology/region of interest is visible.
- The planned surgical target and entry points are visible.
- The tip of the patient's nose is included in the scan and should be the most anterior point on the scan. Having the tip of the patient's nose as the most anterior point on the scan is preferred for the Tracer® registration method.
- The slice thickness is constant throughout the scan.
- No motion artifact is present. Rapidly scroll through the images to make sure they all line up.
- Be aware of phase encoding (ghost) artifacts. If necessary, work with radiology to reduce artifacts.
- The fiducial markers are clearly visible and are not distorted.
- No gantry tilt was used.
- All other aspects of the imaging protocol were followed.

Fiducial marker placement for cranial scans

Note: The following instructions apply to skin fiducial markers (960-991). If you are using a different kind of fiducial marker, follow these recommendations as well as any recommendations from the fiducial marker manufacturer.

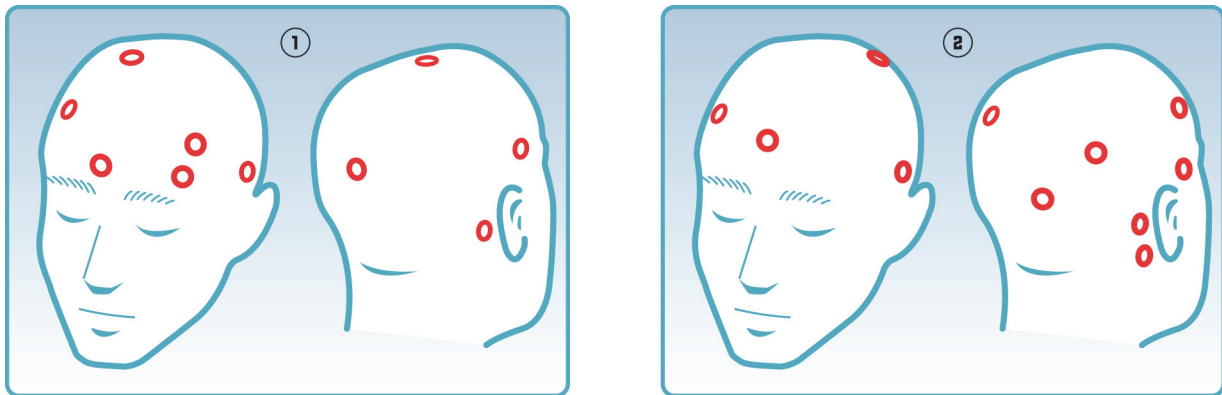
Although imaging may occur at any time prior to surgery, fiducial markers must remain fixed from the time of scanning until after registration in the navigation software. Instruct the patient not to remove or alter the position of the markers. If a marker falls off after the patient has been scanned, leave it off.

Follow these best practices for fiducial marker placement for Touch-n-Go registration or PointMerge® registration.

Good fiducial marker placement

- Place 7 to 11 fiducial markers.
- Distribute the fiducial markers around the patient's head.
- Choose locations where the skin is taut. Avoid areas with loose skin such as the cheeks and under the eyes.
- Choose locations where the fiducial markers will not be depressed or shifted when the patient is lying in the scanner or when the patient is positioned for surgery.
- The mastoid behind the ear is an ideal location for fiducial markers. Place the markers high enough on the mastoid that the scan will encompass them.
- Place more fiducial markers near the surgical area of interest.
- It may be helpful to place 2 markers near each other on one side of the head to help the surgeon confirm correct image orientation.

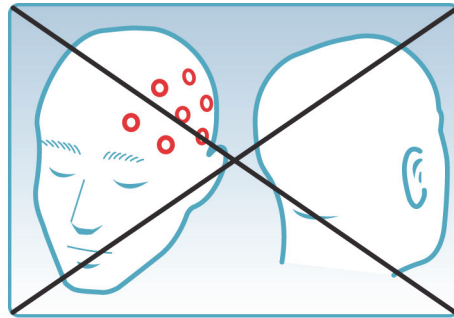
Examples of good fiducial marker placement



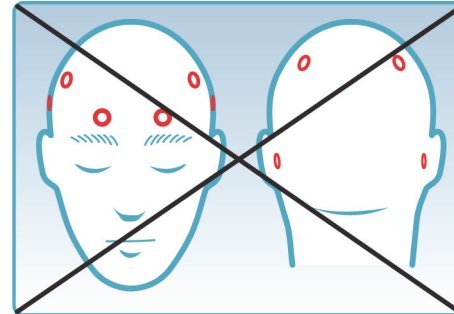
- ① Good fiducial marker placement for anterior and lateral surgical approaches
- ② Good fiducial marker placement for posterior surgical approaches

Poor fiducial marker placement

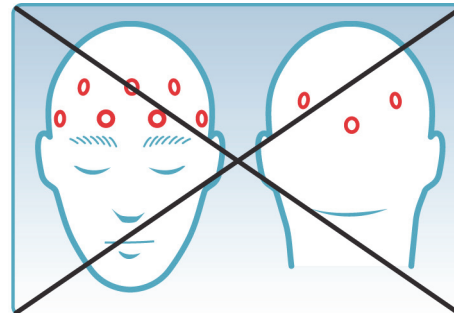
- Do not place all fiducial markers in one concentrated location or on one side of the head.



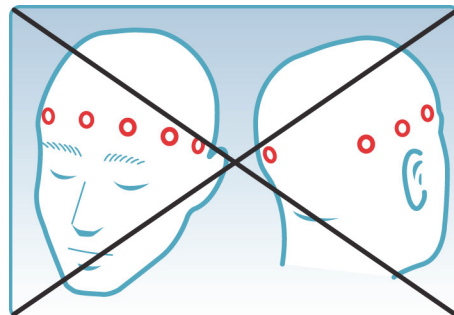
- Do not place fiducial markers in a symmetrical pattern. That is, do not place markers in the same locations on both sides of the head. Also, do not place the markers such that they form squares or triangles with equal-length sides.



- Do not place fiducial markers in a repeating pattern.



- Do not place fiducial markers in a straight line.



Placing fiducial markers

To place the fiducial markers on the patient:

1. Choose a site where the skin is taut. Shave a small patch of hair (approximately one inch square) at the site where you will place the fiducial marker.
2. Clean the site with alcohol to strengthen the marker's adhesion to the skin. Allow the site to dry thoroughly.

Note: If the patient is diaphoretic, you may wish to apply adhesive.

3. Remove the paper from the adhesive backing on the marker, and place the marker at the prepared site.

Note: Make sure that the center dot is removed from the fiducial marker.

4. Mark the skin with an indelible ink pen through the hole in the center of the fiducial marker.
5. Place 7 to 11 markers in this manner.

Distribute the markers around the patient's head as described in the best practices for fiducial marker placement.

6. Ensure positioning in the scanner does not shift any of the fiducial markers.
7. Image the patient according to the appropriate protocol given in this document.

Cranial C protocol

Procedures	Software in which the scans can be used
DBS and stereotactic procedures	• FrameLink™ • StimPilot®

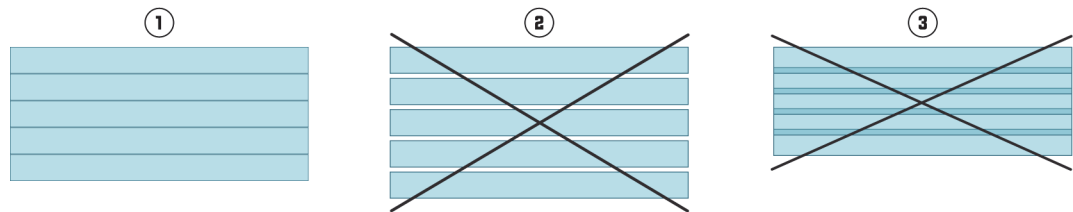
Note: If the patient has WayPoint™ anchors implanted for the STarFix™ platform, refer to the instructions for use of the anchors for additional scan requirements. WayPoint™ anchors and the STarFix™ platform are products of FHC, Inc.

Cranial C scan requirements

Contrast Contrast agents may be injected before scanning.

Slices

- Scan contiguous slices. (Slice spacing must equal slice thickness. Make sure that there is no gap between slices.)



- ① Correct: contiguous slices with no gap and no overlap
- ② Incorrect: gap between slices
- ③ Incorrect: overlap of slices
- Use a constant slice thickness.
- Use a slice thickness of 1 mm or less, which usually produces the highest quality data set for surgical planning and navigation.
 - Any fractional slice thickness up to 3 mm is acceptable. However, as slice thickness increases, surgical planning and navigation performance can be impacted.
 - 3 mm is the largest slice thickness acceptable for use with the FrameLink™ and StimPilot® software.
- Axial slices are preferred.

Size and pixels

- Use a square image matrix of 256 x 256 pixels or 512 x 512 pixels.
- Use square pixels.

Cranial C CT scans only

- Use a standard soft tissue algorithm.
- Do not use gantry tilt.
- Axial/helical scans are acceptable using a pitch ratio of 1:1. If you use helical scans, make sure that you do not see image artifacts in the reconstructed image slices.
- Use a circular (or square) field of view (FOV). Use the smallest FOV to encompass the region of interest, which is usually 28 cm to 32 cm (280 mm to 320 mm).
Include AC/PC structures, target region, entry region (required for frameless scans), and stereotactic frame (required for the registration scan).

Cranial C MR scans only

- Do not use oblique slices. Scan along the axis of the magnet bore.
- Use single-echo scans. Do not use multi-echo scans.
- Any MR imaging sequence can be used to show anatomy/pathology. However, if the scans will be merged, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, and MRA have not been evaluated. Scans taken in the same Frame Of Reference as the MR-T1, MR-T2, or MR-PD may still be used if merged with Identity Merge.
- MR 3D volume acquisition is acceptable as long as the scan can be reconstructed in a way that conforms to all requirements of the imaging protocol.

Scans to merge

If you intend to merge two or more exams using StealthMerge® software, ensure that multiple identifiable landmarks and the skull base are included in all of the scans to enable matching.

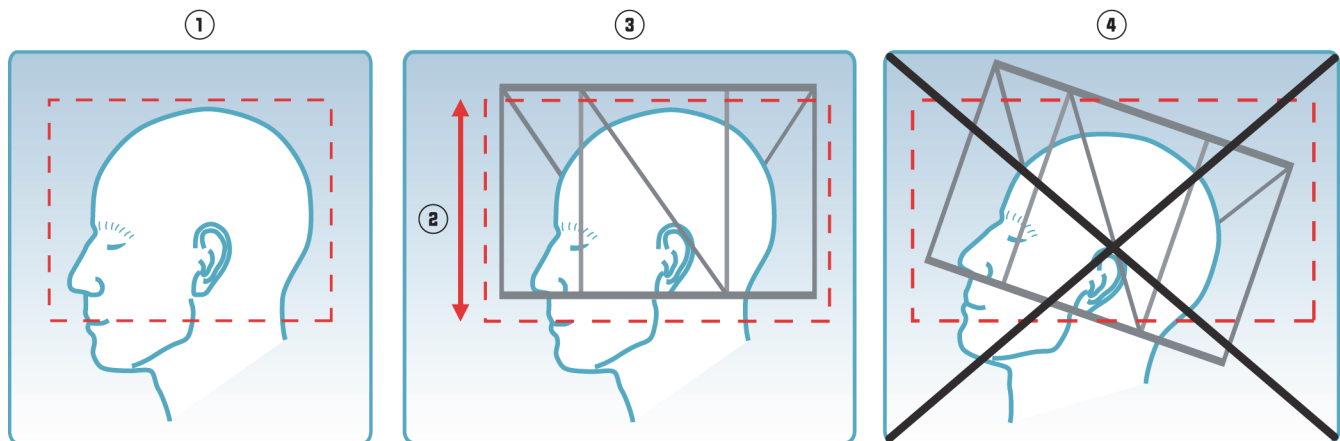
CT, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, MEG, CTA, and MRA have not been evaluated.

Scan region

Scan from the superior aspect of the horizontal portion of the mandible through the top or vertex of the cranium. Include an air gap above the superior aspect of the head. Include bone fiducial markers, the ears, maxillary teeth, and the tip of the nose.

Ensure that the tip of the patient's nose is included in the scan and that it is the most anterior point on the scan. Also, start the scan above any dental work to avoid creating artifacts.

These images show the typical scan region for DBS scans. Include the localizer frame with the 9 required rods in a stereotactic scan (see Figure 1 on page 15 for more information). Minimize the angle between the vertical localizer rods and the superior-inferior image axis.



- ① Scan region without localizer
- ② Superior-inferior image axis
- ③ Ideal scan region with minimal localizer tilt
- ④ Too much angle between the vertical localizer rods and the superior-inferior image axis

Patient position

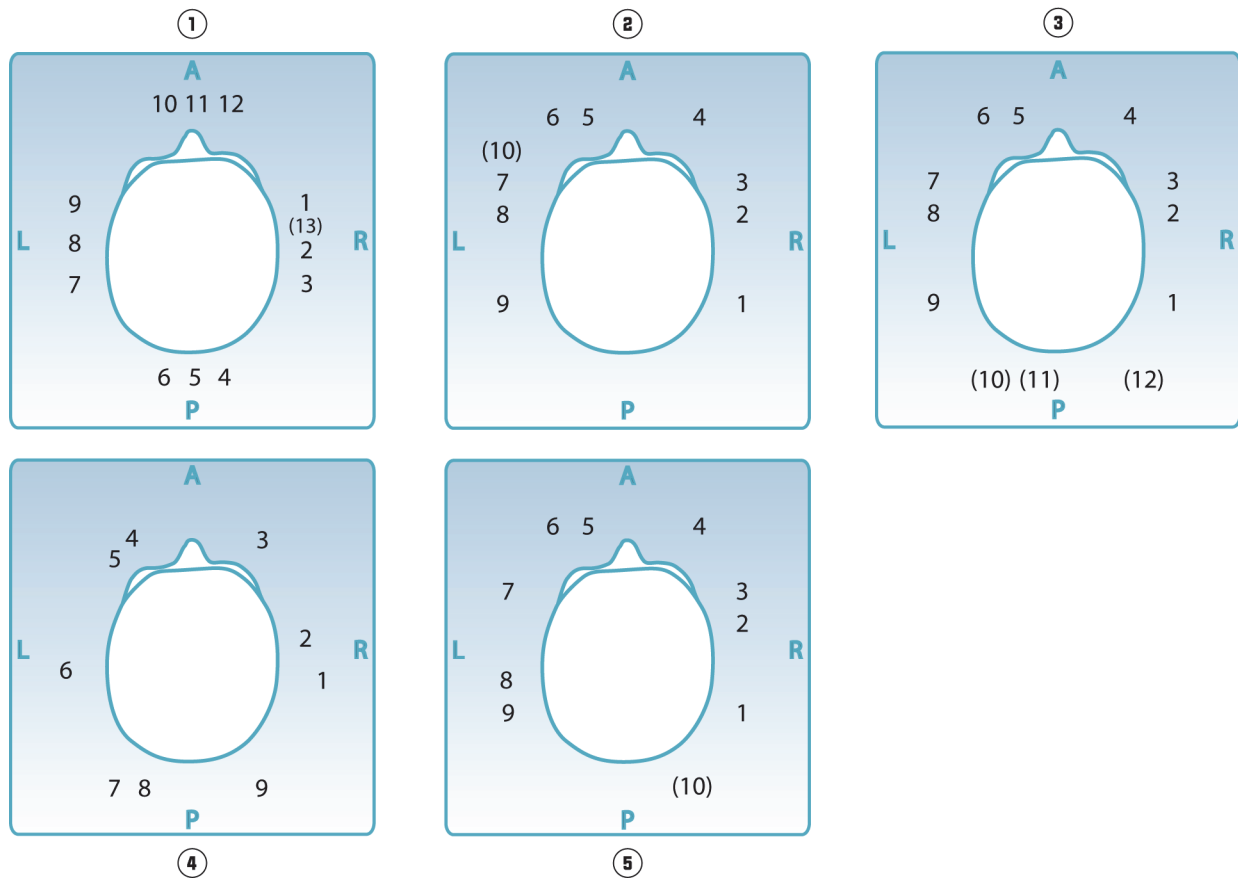
- Make sure that the patient anatomy is oriented as close as possible to LPS space (the left-right, anterior-posterior, and inferior-superior axes).
 - Separate the patient's head from the scanner headrest with towels or foam.
Use padding to prevent patient motion, but make sure that the padding does not distort the fiducial markers or the skin.
Make sure that the patient's ears do not touch the sides of the headrest, and that they are not pushed away from their normal position.
-

Archive format Archive the scan in an uncompressed file format.

Cranial C scan examination

The surgeon or imaging technologist should examine the completed scan to verify the following quality criteria:

- The patient image orientation is correct, and the patient anatomy is lined up with the left-right, anterior-posterior, and inferior-superior axes.
- The total region of interest is visible.
- The planned surgical target and entry points are visible.
- The tip of the patient's nose is included in the scan and should be the most anterior anatomical point on the scan.
- The slice thickness is constant throughout the scan.
- No motion artifact is present. Rapidly scroll through the images to make sure they all line up.
- Be aware of phase encoding (ghost) artifacts. If necessary, work with radiology to reduce artifacts.
- No gantry tilt was used.
- For stereotactic scans, the 9 required rods are visible and are in the correct orientation. Rods 1 through 9 (shown in Figure 1) are required for each frame.

Figure 1: Rod numbering

- ① Fischer frames
- ② Leksell CT frames
- ③ Leksell MR frames
- ④ Integra CRW® frame: BRW-LF (CRW is a trademark of Integra Burlington MA, Inc.)
- ⑤ Integra CRW® frames: Luminant CT and UCLF CT

Note: The rod numbers shown in parentheses may not be available on all versions of the frames.

- All other aspects of the imaging protocol were followed.

Cranial D protocol

Procedures	Software in which the scans can be used
DBS and stereotactic procedures	Synergy® Cranial (This protocol does not apply if you are using Synergy® Cranial software version 2.2.x or earlier.)

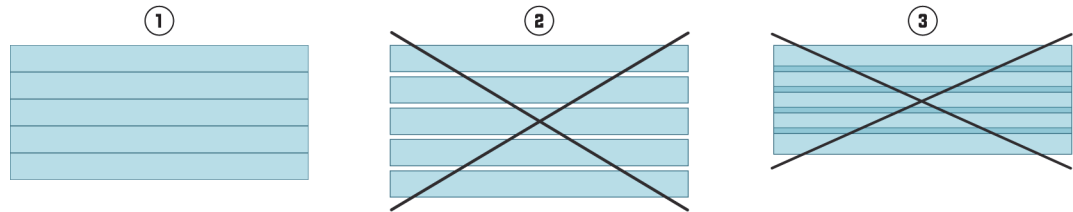
Note: If the patient has WayPoint™ anchors implanted for the STarFix™ platform, refer to the instructions for use of the anchors for additional scan requirements. WayPoint™ anchors and the STarFix™ platform are products of FHC, Inc.

Cranial D scan requirements

Contrast Contrast agents may be injected before scanning.

Slices

- Scan contiguous slices. (Slice spacing must equal slice thickness. Make sure that there is no gap between slices.)



- ① Correct: contiguous slices with no gap and no overlap
 - ② Incorrect: gap between slices
 - ③ Incorrect: overlap of slices
- Use a constant slice thickness.
 - Use a slice thickness of 1 mm or less, which usually produces the highest quality data set for surgical planning and navigation.
 - Any fractional slice thickness up to 3 mm is acceptable. However, as slice thickness increases, surgical planning and navigation performance can be impacted.
 - 3 mm is the largest slice thickness acceptable for cranial scans.
 - Axial slices are preferred.

Size

Use a square or rectangular image matrix of up to 1024 x 1024 pixels.

Note: Scans that are larger than 512 x 512 pixels cannot be used in Synergy® Cranial software version 2.2.x or earlier.

Cranial D CT scans only

- Use a standard soft tissue algorithm.
- Do not use gantry tilt.
- Axial/helical scans are acceptable using a pitch ratio of 1:1. If you use helical scans, make sure that you do not see image artifacts in the reconstructed image slices.
- Use a circular (or square) field of view (FOV). Use the smallest FOV to encompass the region of interest, which is usually 28 cm to 32 cm (280 mm to 320 mm).
Include AC/PC structures, target region, entry region (required for frameless scans), and stereotactic frame (required for the registration scan).

Cranial D MR scans only

- Do not use oblique slices. Scan along the axis of the magnet bore.
- Use single-echo scans. Do not use multi-echo scans.
- Any MR imaging sequence can be used to show anatomy/pathology. However, if the scans will be merged, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, and MRA have not been evaluated. Scans taken in the same Frame Of Reference as the MR-T1, MR-T2, MR-PD, or FLAIR may still be used if merged with Identity Merge.
- MR 3D volume acquisition is acceptable as long as the scan can be reconstructed in a way that conforms to all requirements of the imaging protocol.

Scans to merge

If you intend to merge two or more exams using StealthMerge® software, ensure that multiple identifiable landmarks and the skull base are included in all of the scans to enable matching.

CT, MR-T1, MR-T2, MR-PD, FLAIR, and combinations thereof, have been evaluated and found effective for use with StealthMerge® software. Other modalities such as SPGR, MPRAGE, MEG, CTA, and MRA have not been evaluated.

If you intend to merge O-arm® exams with preoperative exams, you may use any imaging mode, except when using an O-arm® O-1000 system. For O-arm® O-1000 systems, use the high definition 3D or enhanced cranial 3D modes.

Scan region

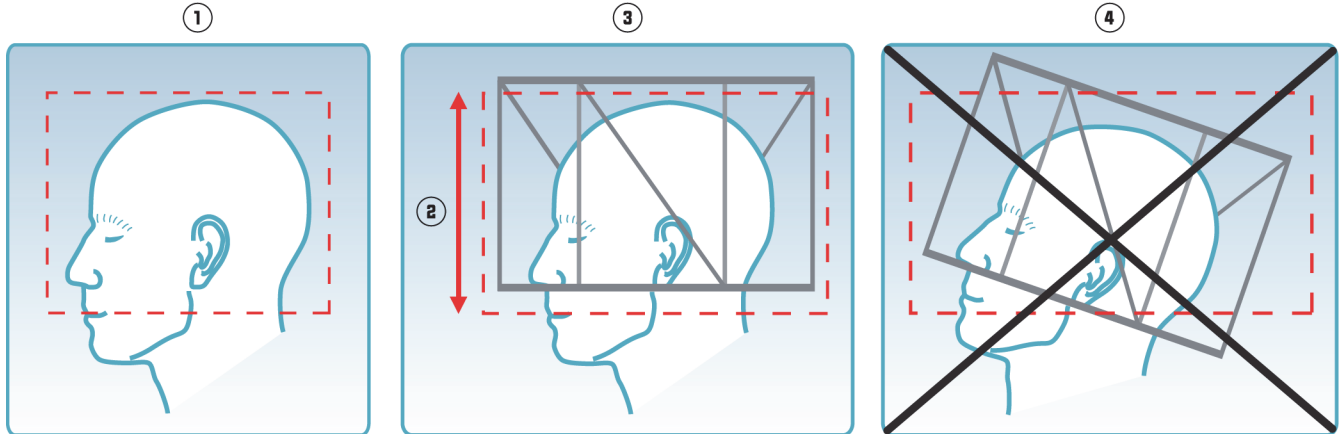
Scan from the superior aspect of the horizontal portion of the mandible through the top or vertex of the cranium. Include an air gap above the superior aspect of the head. Include bone fiducial markers, the ears, maxillary teeth, and the tip of the nose.

Ensure that the tip of the patient's nose is included in the scan and that it is the most anterior point on the scan. Also, start the scan above any dental work to avoid creating artifacts.

These images show the typical scan region for DBS scans. Include the localizer frame with the required rods in a stereotactic scan.

- If the frame will be registered manually in the software, rods 1 through 9 are required in the scan (see Figure 2 page 19 for more information).
- If the frame will be registered automatically in the software, at least 6 rods are required in the scan, and at least 1 of the 6 must be a diagonal rod. However, consider including rods 1 through 9 in case manual frame registration becomes necessary.

Minimize the angle between the vertical localizer rods and the superior-inferior image axis.



- ① Scan region without localizer
- ② Superior-inferior image axis
- ③ Ideal scan region with minimal localizer tilt
- ④ Too much angle between the vertical localizer rods and the superior-inferior image axis

Patient position

Separate the patient's head from the scanner headrest with towels or foam.

Use padding to prevent patient motion, but make sure that the padding does not distort the fiducial markers or the skin.

Make sure that the patient's ears do not touch the sides of the headrest, and that they are not pushed away from their normal position.

Archive format

Archiving the scan in an uncompressed file format is preferred. If you compress the scan, use a lossless compression method, such as, JPEG lossless or JPEG2000 lossless.

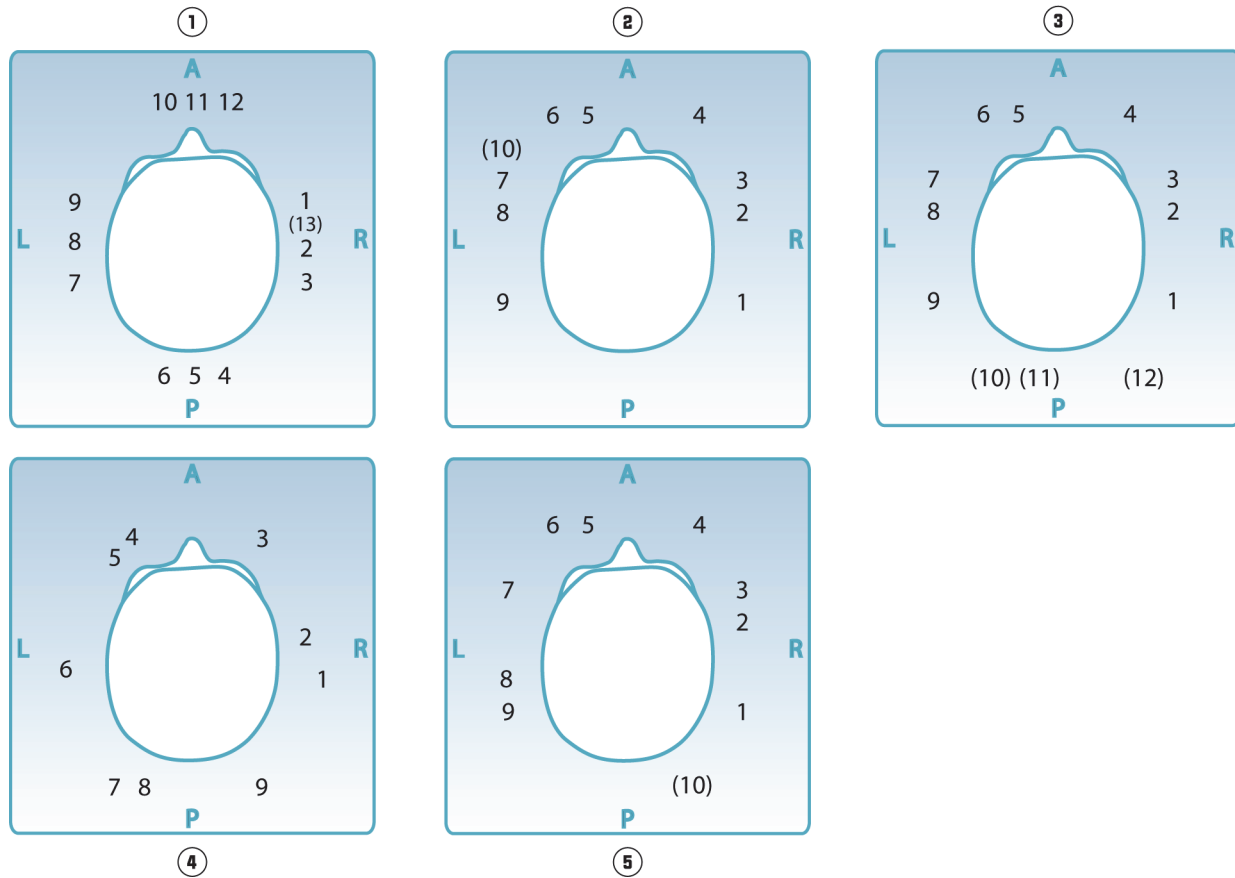
Note: Compressed scans cannot be used in Synergy® Cranial software version 2.2.x or earlier.

Cranial D scan examination

The surgeon or imaging technologist should examine the completed scan to verify the following quality criteria:

- The patient image orientation is correct, and the patient anatomy is lined up with the left-right, anterior-posterior, and inferior-superior axes.
- The total region of interest is visible.
- The planned surgical target and entry points are visible.
- The tip of the patient's nose is included in the scan and should be the most anterior anatomical point on the scan.
- The slice thickness is constant throughout the scan.
- No motion artifact is present. Rapidly scroll through the images to make sure they all line up.
- Be aware of phase encoding (ghost) artifacts. If necessary, work with radiology to reduce artifacts.
- No gantry tilt was used.

- For stereotactic scans make sure that the required rods are visible and are in the correct orientation.
 - If the frame will be registered manually in the software, rods 1 through 9 are required.
 - If the frame will be registered automatically in the software, at least 6 rods are required in the scan, and at least 1 of the 6 must be a diagonal rod. However, consider including rods 1 through 9 in case manual frame registration becomes necessary.

Figure 2: Rod numbering

- ① Fischer frames
- ② Leksell CT frames
- ③ Leksell MR frames
- ④ Integra CRW® frame: BRW-LF
- ⑤ Integra CRW® frames: Luminant CT and UCLF CT

Note: The rod numbers shown in parentheses may not be available on all versions of the frames.

- All other aspects of the imaging protocol were followed.

ENT protocol

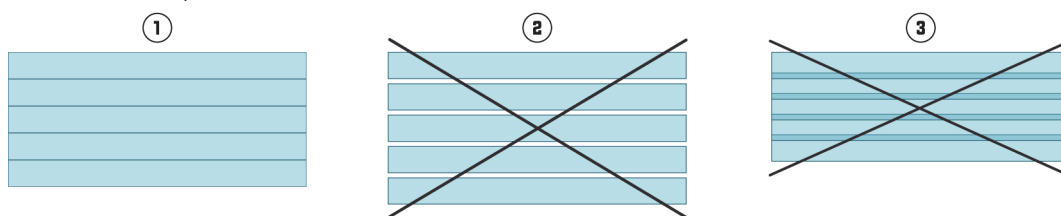
Procedures	Software in which the scans can be used
Anterior skull base and sinus procedures	• Fusion® ENT • LandmarX® elemENT • LandmarX® eNV®

ENT scan requirements

Contrast Contrast agents may be injected before scanning.

Slices

- Scan contiguous slices. (Slice spacing must equal slice thickness. Make sure that there is no gap between slices.)



- ① Correct: contiguous slices with no gap and no overlap
- ② Incorrect: gap between slices
- ③ Incorrect: overlap of slices
- Use a constant slice thickness.
- Use a slice thickness of 1 mm or less, which usually produces the highest quality dataset for surgical planning and navigation.
 - Any fractional slice thickness up to 2 mm is acceptable. However, as slice thickness increases, surgical planning and navigation performance can be impacted.
 - 2 mm is the largest slice thickness acceptable for use with the ENT application.
- Axial slices are preferred.

Size

- Use a square image matrix of 256 x 256 pixels or 512 x 512 pixels.
- Use square pixels.

ENT CT scans only

- Use a standard soft tissue algorithm.
- Axial/helical scans are acceptable using a pitch ratio of 1:1. If you use helical scans, make sure that you do not see image artifacts in the reconstructed image slices.
- Use a circular (or square) field of view (FOV). Use the smallest FOV to encompass the region of interest, which is usually up to 25 cm (250 mm).
Include the top of the head, the skull base, and the nose. If the scan will be merged with other scans using ENT Scan Merge software, make sure that there is an air gap around the head.
- Do not use gantry tilt.

ENT MR scans only

- Do not use oblique slices. Scan along the axis of the magnet bore.
- Use single-echo scans. Do not use multi-echo scans.
- Any MR imaging sequence can be used to show anatomy/pathology. However, if the scans will be merged, MR-T1, MR-T2, and combinations thereof, have been evaluated and found effective for use with ENT Scan Merge and StealthMerge® ENT software. Other modalities such as SPGR, MPRAGE, and MRA have not been evaluated.
- MR 3D volume acquisition is acceptable as long as the scan can be reconstructed in a way that conforms to all requirements of the imaging protocol.

Scans to merge

If you intend to merge two or more exams using ENT Scan Merge or StealthMerge® ENT software, ensure that multiple identifiable landmarks and the skull base are included in all of the scans to enable matching.

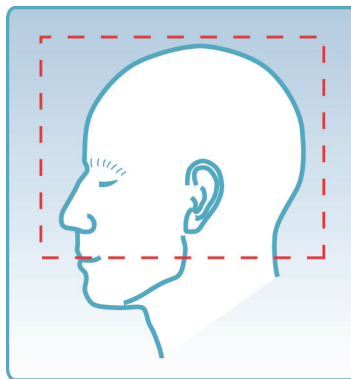
CT, MR-T1, MR-T2, and combinations thereof, have been evaluated and found effective for use with ENT Scan Merge and StealthMerge® ENT software. Other modalities such as SPGR, MPRAGE, MEG, CTA, and MRA have not been evaluated.

Scan region

Scan from the superior aspect of the horizontal portion of the mandible through the top or vertex of the cranium. Include an air gap above the superior aspect of the head. Include the skull base, the ears, maxillary teeth, and the tip of the nose.

Ensure that the tip of the patient's nose is included in the scan and that it is the most anterior point on the scan. Also, start the scan above any dental work to avoid creating artifacts.

The image below shows the typical scan region for ENT anterior skull base and sinus procedures.

**Patient position**

Place the patient's head on a headrest, a small firm donut, or a folded towel on the scanner table.

If the patient cannot remain still, use a headrest.

- Separate the patient's head from the headrest with towels or foam.
- Use padding to prevent patient motion, but make sure that the padding does not distort or shift the skin.
- Make sure that the patient's ears do not touch the sides of the headrest, and that they are not pushed away from their normal position.

Archive format

Archive the scan in an uncompressed file format.

ENT scan examination

The surgeon or imaging technologist should examine the completed scans to verify the following quality criteria:

- The patient image orientation is correct.
- The total pathology/region of interest is visible.
- The planned surgical target and entry points are visible.
- The tip of the patient's nose is included in the scan and should be the most anterior point on the scan. Having the tip of the patient's nose as the most anterior point on the scan is preferred for the Tracer® registration method.
- The slice thickness is constant throughout the scan.
- No motion artifact is present. Rapidly scroll through the images to make sure they all line up.
- Be aware of phase encoding (ghost) artifacts. If necessary, work with radiology to reduce artifacts.
- No gantry tilt was used.
- All other aspects of the imaging protocol were followed.

Spine protocol

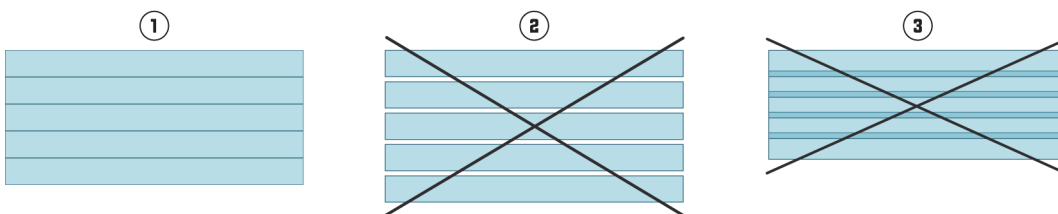
Procedures	Software in which the scans can be used
All navigated spine procedures	• Synergy® Spine • Synergy® Spine and Trauma • Spine 3D • Synergy® Experience TLIF Procedure Solution

Spine scan requirements

Contrast Contrast agents may be injected before scanning.

Slices

- Scan contiguous slices. (Slice spacing must equal slice thickness. Make sure that there is no gap between slices.)



- ① Correct: contiguous slices with no gap and no overlap
- ② Incorrect: gap between slices
- ③ Incorrect: overlap of slices
- Use a constant slice spacing.
- Use a slice thickness of 1 mm or less, which usually produces the highest quality data set for surgical planning and navigation.
 - Any fractional slice thickness up to 2 mm is acceptable. However, as slice thickness increases, surgical planning and navigation performance can be impacted.
 - 2mm is the largest slice thickness acceptable for use with the Spine application.
- Axial slices are preferred.

Size and pixels

- Use a square image matrix of 256 x 256 pixels or 512 x 512 pixels.
- Use square pixels.

Spine CT scans only

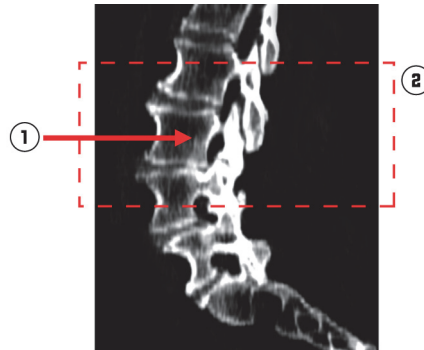
- Use a standard soft tissue algorithm.
- Do not use gantry tilt.
- Axial/helical scans are acceptable using a pitch ratio of 1:1. If you use helical scans, make sure that you do not see image artifacts in the reconstructed image slices.
- Use a circular (or square) field of view (FOV). Use the smallest FOV to encompass the region of interest, which is usually up to 18 cm (180 mm).
Completely encompass all vertebrae of interest, including the spinous and transverse processes.

**Spine MR
scans only**

- Do not use oblique slices. Scan along the axis of the magnet bore.
- Use single-echo scans. Do not use multi-echo scans.
- Any MR imaging sequence can be used to show anatomy/pathology.
- MR 3D volume acquisition is acceptable as long as the scan can be reconstructed in a way that conforms to all requirements of the imaging protocol.

Scan region

- Scan coverage should include one-half vertebra above and below the region of interest. This image shows a sample scan region for a lumbar spine scan.



- ① Vertebra of interest
- ② Minimum scan region

- When imaging the sacrum, scan past and include the sciatic notches.

Archive format Archive the scan in an uncompressed file format.

Spine scan examination

The surgeon or imaging technologist should examine the completed scan to verify the following quality criteria:

- The patient image orientation is correct.
- The total pathology/region of interest is visible.
- The planned surgical target and entry points are visible.
- The slice spacing is constant throughout the scan.
- No motion artifact is present. Rapidly scroll through the images to make sure they all line up.
- Be aware of phase encoding (ghost) artifacts. If necessary, work with radiology to reduce artifacts.
- No gantry tilt was used.
- All other aspects of the imaging protocol were followed.

Transfer the scan

To transfer a scan to a StealthStation® system, archive the scan from the scanner to a CDR/DVR or USB drive, or transfer the scan electronically to the Medtronic Computer-Assisted Surgery system via a DICOM network. Do not archive or transfer scout images.

If the StealthStation® system includes DICOM query software, users can query the PACS to retrieve images.

Assistance

For questions about the Imaging Protocols, contact your local Medtronic Navigation Clinical Specialist or call technical support at +1 800 595 9709 or +1 720 890 3160.

