- Place a cold compress or ice pack wrapped in a dry cloth along the skin staples or SMS if it can be safely clinically accomplished during the MR exam. (This will serve as a heat sink for any power deposition that may occur, thus decreasing the likelihood of a clinically significant thermal injury or burn to the adjacent tissue.)

Assistive Technology

Assistive technology includes assistive, adaptive, and rehabilitative devices for individuals with disabilities.

Mobility Tools

Orthoses and prosthetic limbs must be removed from the patient prior to the MR exam.

Hearing Tools

Hearing aids must be removed from the patient prior to the MR exam.

Vision Tools

Devices for visual impairment include eSight electronic eyeglasses (eSight Corporation) and Brainport V100 oral electronic vision aids (Wicab, Inc.). Both of these devices must be removed prior to the MR exam.

Another device for visual impairment is the Argus II Retinal Prosthesis System (Second Sight Medical Products, Inc.) used in patients with severe to profound retinitis pigmentosa. Also known as the Bionic Eye or Retinal Implant, it provides electrical stimulation of the retina to induce visual perception in blind individuals.

The Argus II system includes a retinal implant, a miniature video camera housed in the patient's glasses, and a small computer or video processing unit (VPU) worn by the patient. The Argus II retinal implant is MR Conditional so MR imaging of these patients is possible, but only on a 1.5-Tesla or 3.0-Tesla system and only if all other manufacturer specified conditions are met. However, the patient's glasses and the VPU must be removed before the patient enters the MR environment.

SCANNING PATIENTS CONTRAINDICATED FOR MR

Although there is a significant number of implantable medical devices that are either MR Safe or MR Conditional, MR technologists may be faced with the following scenarios that require significant effort to provide safe patient care:

- Patient with device with no known MR safety label
- Patient with an MR Unsafe device
- Patient with MR Conditional device and abandoned leads
- Patient with MR Conditional pulse generator but MR Unsafe leads
- Patient with an MR Conditional device, but the manufacturer's specific guidance cannot be met
- Patient with devices separately labeled MR Conditional, but not as a system

These scenarios (and possibly others) require the MR technologist to contact ***an MR Radiologist*** for further instructions or guidance.

When assessing the risk of any implanted device or object in the MR environment, consider the answers to three basic questions that address the primary hazards: B_0, B_1, and dB/dt.

1. **How will the device be affected by the static magnetic field?**

   Is the device or object ferromagnetic?

   What field strength was used during the testing of the device?

   Will the device or object be located within the bore during the exam?

   Is the device or object located near a vital organ or structure?

   Will the spatial gradient (dB/dx) through which the device must pass exceed the manufacturer's specifications?

2. **How will the device be affected by the RF magnetic fields?**

   Will the device or object be placed within the volume irradiated by RF during the exam?

   Is the device or object made of metal?

   What is the shape of the device or object?

   What is the SAR limit for the device?

3. **How will the device be affected by the gradient magnetic fields?**

   Is the device a stimulator?

   Is there a dB/dt or slew rate limit for the device?

The decision "to scan or not to scan" is the responsibility of the MR Radiologist and is ultimately based upon whether the risks of the potential consequences of the device interactions with the various magnetic fields are outweighed by the benefits of the exam. If MR is the only modality that can answer a diagnostic question and the benefit outweighs the potential risks, scanning the patient may be possible – but only if the following Five Step process (MHRA 2015) is completed and documented prior to the exam.

1. A comprehensive risk assessment must be completed with full involvement of a multidisciplinary team that includes the MR Radiologist, an MR Safety Officer/MR

technologist, a relevant specialist clinician, and the referring physician. The following items must be included in the assessment:

- Consideration of alternative imaging modalities
- Advice from the implant manufacturer
- Available professional body recommendations
- Published evidence about the device
- Available data about the device
- Assessment of potential magnetic field interactions, heating, and induced currents
- Assessment of possible artifacts
- MR scanner parameters, including consideration of a lower static magnetic field strength and/or gradients (that may require referral to another MR facility)

2. Appropriate precautions to minimize the risk must be identified and implemented. These include (but are not limited to):
   - Appropriate programming of the implanted device
   - Suitable monitoring (e.g., SAR levels, physiologic signals) during the scan provided by appropriately trained personnel to operate and/or interpret the results
   - SAR exposure including the consideration of methods to reduce it (e.g., reduced flip angles, longer TRs, use of transmit/receive coils)
3. Provisions must be established to ensure that a suitable clinician is available and in the MR Department at the time of the exam (e.g., a cardiologist or cardiac physiologist for cardiac devices)
4. Provisions must be established for post-scan evaluation of the patient
5. The MR Radiologist must obtain patient consent

The MR facility should never feel pressured into adopting this process if the team does not feel confident in the resources available to them. Instead, it may be appropriate to refer a particular patient to another facility with experience in either scanning the particular device or in the risk assessment process.

MR Technologist Worksheet for Magnetic, Conducting, and/or Metallic Implant

TRA developed a worksheet (Figure 15) to standardize how to document the MR safety status of implanted devices and the decision making process necessary to determine if the MR system meets the manufacturer's specified testing conditions. **The MR technologist must organize the information needed by the MR Radiologist** to determine if risks are outweighed by benefits of the MR exam for a particular patient.

MR Technologist Worksheet for Magnetic, Conducting, and/or Metallic Implant

Exam	Implant Description

1. GENERAL INFORMATION		
Location of foreign object/device/implant in body		
Are there x-rays/CTs of object in question?	YES	NO
Operative notes or implant card available? If YES, include copy.	YES	NO
Manufacturer insert available? If YES, include copy.	YES	NO
MR safety label or status (Circle one) SAFE	Conditional	NOT SURE

2. MANUFACTURER SPECIFIED CONDITIONS/CRITERIA	MR System	OBJECT
System static magnetic field and specified restrictions for object		
System max spatial gradient (dB_o/dx) and specified restrictions for object		
System RF and specified restrictions for object		
System slew rate and specified restrictions for object		
Manufacturer criteria for safe MR scanning can/have been met.	YES	NO

MR Technologist Signature	Date/Time

Complete Sections 3, 4, and 5 for any foreign body or implant/object/device with *unknown* MR safety status. ***MR exam must be authorized by MR Radiologist who must obtain patient consent.***

3. STATIC MAGNETIC FIELD (B_o) CONSIDERATION			
Is object ferromagnetic? NO		NOT SURE	YES
Is object near vital organ or structure?		NO	YES
If non-ferrous and metallic, is object large enough for Lenz's force issues?		NO	YES
B_o RISK		MINIMAL	HIGH

4. TIME VARYING RF CONSIDERATION			
Will object be exposed to RF energy? NO		NOT SURE	YES
Can transmit/receive coil be used		YES	NO
What is composition/shape/length of object?			
RF RISK		MINIMAL	HIGH

5. TIME VARYING GRADIENT CONSIDERATION		
Is this object a stimulator?	NO	YES
Is there dB/dt limit for object?	NO	YES
Is there dB/dx/dt (slew rate) limit for object?	NO	YES
GRADIENT RISK	MINIMAL	HIGH

MR RADIOLOGIST'S AUTHORIZATION FOR MR PROCEDURE	
MR Radiologist Signature	Date/Time

Figure 15. MR Technologist Worksheet for Magnetic, Conducting, and/or Metallic Implant. Available at http://www.triadradiology.com/ (after logging in).