

## **The Pre-MRI Screening Questionnaire: Purpose and Rationale**

Note: This information is relevant to whole body MR systems. For information pertaining to MRI systems dedicated to specific parts of the body, e.g, knee imaging systems, please refer to the appropriate section on [www.mrisafety.com](http://www.mrisafety.com) web site. Patient refers to the person undergoing the MRI procedure. It includes normal subject volunteers for research studies. "MRI environment" refers to all space within the 5 gauss line of the MRI system, which is the field strength established by the FDA as a lowest field strength for which no precautions need be taken. The "MRI magnet room" refers to the room that houses that MRI magnet. Entry to this room is restricted by large doors. The room is large enough so that the missile effect (described below) does not occur outside of this room.

In 1994, the Safety Committee of the Society for Magnetic Resonance (previously designated at the Society for Magnetic Resonance Imaging and presently called the International Society for Magnetic Resonance in Medicine) published screening recommendations and a questionnaire that encompassed all known issues (3). These recommendations were developed as a consensus from an international panel of MR experts and were intended for use as a standard of care at all MR centers. Elster et al. (6) also published a screening recommendation in 1994. This information was similar to the content of the recommendations provided by the Safety Committee.

The initial screening process should involve completion of a pre-MRI questionnaire that is specifically designed to reveal reasons that the patient might have an adverse reaction to the MRI procedure (1-3, 6, 15). The questionnaire must include questions concerning previous surgery, prior exposure to metallic slivers or fragments that may have entered the eye, and pregnancy. The questionnaire should determine whether the patient has on or within their body any implant, material, device and or other items that are considered to be hazardous in the MRI environment, or present a difficulty in achieving high image quality. This includes any device that is electrically, magnetically, or mechanically activated. A diagram of the human body should be provided for the patient to indicate the position of any such object (1, 3, 6, 22, 23).

The screening questionnaire should also be used to obtain additional information on a variety of different topics related to the safe performance of the MRI procedure. For example, questions should be included concerning previous adverse reactions to contrast media that should alert the health care provider to potential problems (1, 3, 6). Questions should be included related to the patient's phase of the menstrual cycle, and the use of oral contraceptives and/or hormone treatment, which are relevant to patients undergoing MRI examinations for suspected gynecologic abnormalities or for breast pathology (3).

### ***Pre-MRI Screening and Metallic Objects***

Numerous studies have assessed the relative safety of performing MR procedures in patients with biomedical implants, materials, or devices (1, 2, 7, 9-18). These studies establish what type of metallic objects a patient may have and yet be permitted into the MRI environment without undo risk.

Investigations have generally demonstrated that an MR procedure may be performed safely in a patient with a implanted metallic object if it is non-ferromagnetic or if it is only minimally attracted by the static magnetic field in relation to the in vivo application of the object (7-17).

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The presence of an electrically, magnetically, or mechanically activated device is usually considered to be a contraindication for an MR procedure (1-21). Therefore, any patient with this type of device typically must be excluded from the MR environment unless, of course, the particular device is documented as being unaffected by the MRI environment (1-3, 8-17).

### ***Pre-MRI Screening for Metallic Foreign Bodies***

All patients that have a history of being injured by a metallic foreign body such as a bullet, shrapnel, or other type of metallic fragment should be thoroughly evaluated prior to entering the MRI environment (1-3). This is particularly important with respect to the static magnetic field of the MRI system because the exposure may cause serious injury as a result of movement or dislodgment of the metallic foreign body. Basic precautions described below should be taken with any type of MR system, regardless of the field strength, magnet type, and the presence or absence of magnetic shielding (1, 2, 5).

The relative risk of injury is dependent upon the ferromagnetic properties of the foreign body, the geometry and dimensions of the object, and the strength of the static magnetic field of the MRI system. The potential for injury is inversely related to the amount of resistance to movement the tissue provides to the object, and whether or not the object is positioned in or adjacent to a particularly sensitive tissue site such as a vital neural, vascular, or soft tissue structure (1, 2, 9-17).

Any individual with an intraocular metallic foreign body has a particularly high risk for significant eye injury if exposed to the static magnetic field of an MRI system (1, 2, 28-32). The single reported case of a vitreous hemorrhage, resulting in blindness, occurred during an MRI procedure performed using a 0.35 Tesla MR system (28). The patient had an intraocular metal fragment, 2.0 X 3.5 mm that moved under the influence of the main magnetic field as the patient exited the MR system (28). This incident emphasizes the importance of screening patients and other individuals with suspected intraocular metallic foreign bodies.

In general, plain film radiography appears to be an acceptable technique for identifying or excluding an intraocular or periorbital metallic foreign body that may present a potential hazard to the patient entering the MRI environment (1, 5, 6, 15, 26, 30). Any patient with a history suggesting the possibility of an intraocular metallic foreign body (e.g., a metal worker exposed to metallic slivers with a history of an eye injury requiring medical attention, a patient with a history of being a metal worker or fabricator, etc.) should have plain film radiographs of the orbits. These radiographs rule-out the presence of a metallic fragment (1, 5, 6, 15, 26, 30). If this plain film radiological exam cannot be performed, the patient should not enter the MRI environment, and such not have the MRI procedure.

If by history a patient is suspected of having a ferromagnetic intraocular foreign body, but has no history of a explicit injury to the eye, has no previous or present symptoms, and has had a plain film radiograph of the orbits that does not demonstrate a radiopaque foreign body, the risk of injury associated with exposure to the MR system is considered to be minimal (1, 3, 5, 6, 26).

If by history a patient is suspected of having a ferromagnetic intraocular foreign body, but since the reported incident in the history has had an MRI exam of the head without difficulty, in an MRI system with the same field strength, the risk of injury associated with exposure to the MR system is considered to be minimal.

In addition to being used to detect metallic objects in the ocular region, plain film radiography should be used when screening a patient for the presence of a metallic object located in any potentially hazardous site of the body (1, 5, 6, 15).

### ***Pre-MRI Screening of Adolescent Patients***

A recent case report illustrates that special precautions are needed for pre-MRI screening of adolescent patients (32). This paper described an incident during which a 12-year-old patient accompanied by his parent completed all routine procedures prior to MRI of the lumbar spine. The pre-MRI screening process applied to this patient included the recommendations and questionnaire developed by the Safety Committee of the Society for Magnetic Resonance (3). The adolescent patient and parent provided negative answers to questions regarding prior injury by metallic objects and the presence of metallic foreign bodies. While entering the MR system room, the adolescent patient appeared to be unusually anxious (32). He was placed in a feet-first, supine position on the scanner table. The patient became more anxious and restless, shifting his positions several times on the table. As the patient was moved slowly towards the bore of a 1.5 Tesla MR system, he complained of pressure in the left eye. The MRI technologist immediately removed him from the MR system and out of the room. Once again, the patient was questioned regarding any previous eye injuries, and again he denied any history of injury or problems. Nevertheless, an intraocular foreign body was suspected. Waters plain films were obtained, with the adolescent patient maintaining upward and downward fixed glazes. The plain films revealed a metallic foreign body in the left orbit, curvilinear in shape and approximately 5 mm in size. Fortunately, the patient did not sustain an injury to the eye during this incident. The patient and parent were counseled regarding the implications of future MR procedures. They were warned of the possibility of significant eye injury related to movement or dislodgment of the metallic foreign body. This case demonstrates that questionnaires may not be sufficient to reveal hazardous situations. The deficiency of questionnaires may be particularly pronounced in adolescents. Whenever parents or guardians fill out the pre-MRI screening questionnaires, there are additional risks because the children may not have disclose previous injuries or accidents.

To avoid accidents with adolescent patients, such patients should have private sessions to learn about the unique hazards associated with the MR environment, to help them recall significant personal history (32).

### ***Pre-MRI Screening and Protection From "Missile Effects"***

The "missile effect" refers to the capability of the fringe field of the static main magnetic field to attract ferromagnetic objects (e.g., oxygen tanks, tools, etc.) into the MR system with a considerable force (1). These objects effectively become missiles that fly into the bore (center hole) of the MRI magnet. The missile effect can pose a significant risk to the patient in the bore of the MR system and anyone in the path of the ferromagnetic object being attracted.

To guard against the missile effect, the area around the MR system must be clearly demarcated and labeled with appropriate warning signs, and monitored by trained technical staff. Patients and other individuals that wish to enter the MRI magnet room are first screened by the MRI Technologist, to remove all objects that may become missiles. Patients and other individuals are educated about the hazards of the fringe field of the magnet, before entering the MR magnet room.

For patients preparing to undergo an MR procedure, all metallic personal belongings (i.e., analog watches, jewelry, etc.) and devices must be removed. If body imaging is being performed, clothing items that have metallic fasteners, loose metallic components, or metallic threads must be removed. These same precautions are necessary for other individuals that may enter the MRI magnet room. An effective means of preventing a ferromagnetic object from inadvertently becoming a missile is to require that patients and accompanying individuals remove all objects (e.g., pens, paperclips, pins) from their pockets and hair before entering the MRI environment.

Wheel chairs and gurneys brought to the MRI environment must be inspected for the presence of ferromagnetic components. Only non-ferromagnetic wheel chairs and gurneys are allowed in the MRI magnet room. There are several commercially-available, MRI safe wheelchairs and gurneys that may be used to transport and support non-ambulatory patients to and from the MRI environment.

Ferromagnetic oxygen tanks, that may accompany patients in wheelchairs and gurneys, pose a particularly severe hazard, and are strictly prohibited from entering the MRI magnet room. Non-ferromagnetic MRI-compatible oxygen delivery systems are commercially available.

Extraction of a ferromagnetic object from a superconductive MR magnet often requires that the main magnetic field be brought to zero field strength, in a "controlled run-down" of the main magnetic field. Due to service costs, loss of cryogens and loss of clinical use, such extraction costs ten thousand dollars or more.

### ***Pre-MRI Screening and Pregnant Patients***

According to the recommendations provided by the Safety Committee of the Society for Magnetic Resonance Imaging, MRI procedures may be used in pregnant patients if other nonionizing forms of diagnostic imaging are inadequate or if the MRI examination provides important information that would otherwise require a diagnostic procedure that requires ionizing radiation (e.g., computed tomography, fluoroscopy, etc.).

The guidelines issued by the United States Food and Drug Administration state that the safety of MR when used to image the fetus has not been established or proved. Patients should be provided this information, but should also be informed that there are presently no known deleterious effects related to the use of MR procedures during pregnancy (1, 2, 4, 15).

A patient who is pregnant or suspects that she is pregnant must be identified prior to entering the MRI environment. The risks versus benefits of the examination must be established for this patient. Typically, MRI procedures are conducted in pregnant patients only for necessary medical diagnosis. Typically, such patients do not participate in MRI research studies.

### ***Pre-MRI Screening and Tattoos***

In the questionnaire, the patient is asked if he or she has ever had any type of permanent coloring technique (i.e., tattooing) applied to any part of the body. Tattooing includes cosmetic appellations such as eyeliner, lip-liner, and decorative designs on the skin. Questions regarding tattoos are necessary because a small number of patients (fewer than 10) have experienced transient skin irritation and or cutaneous swelling at the tattoo site in association with MR procedures. Tattoos may also create image artifacts which compromise the usefulness of the images.

Tatoos with pigments containing iron oxide or other ferromagnetic substances are more likely to cause adverse effects (8, 29-30). Pigments that are black or blue in color are likely to be ferromagnetic. The pigments interact with the electromagnetic fields used in MRI procedures, producing localized heating (8, 28). One patient developed eye irritation from her makeup (which contained ferromagnetic particles) which was displaced from her eyelid onto her eye during the MR procedure (8).

Only a few patients with tattoos have had adverse effects directly related to their tattoos, and these have been mild and short term. The risk in performing an MR procedure in a patient that has a tattoo is unlikely to outweigh the benefit of the examination, in particular if the diagnostic information provided by MRI is critical to the care of the patient. Overall, the risk of tattoos is considered to be minor.

If a patient with a tattoo requires an MR procedure, the patient should be informed of the relative minor risk associated with the tattoo. Patients with eye makeup should be informed of the hazards related to the eye makeup, and request that they remove the makeup (if possible) prior to the MR procedure. In addition, the patient should be instructed to quickly inform the MR operator if any unusual sensations are felt at the site of the tattoo during the MR procedure. Patients with tattoos located on extremities should be positioned in the MR system to avoid direct contact with the body coil or surface coils. The patient's arms should be placed away from the side of the magnet, using straps to hold the arms close to the body. Foam rubber pads may be placed in between the site of the tattoo and the coil. Patients with tattoos should be closely monitored throughout the entire scanning session. The MR technologist may apply a cold compress to the tattoo as a prophylactic measure to minimize the risk of tissue heating.

### ***About the Pre-MRI Screening Form***

The Pre-MRI Screening Form is a comprehensive survey designed to avoid adverse events, injuries, or problems associated with using an MRI system.

The Pre-MRI Screening Form asks important questions about the patient's past history that might be relevant to the safety precautions of the MRI environment. For example, the patient is questioned as to whether he or she had a previous surgery. The answer to this question helps the MR Technologist determine whether an object may have been implanted in the patient's body that could be a risk to the patient in the MRI environment.

Additionally, the form asks for the dates and locations of previous diagnostic imaging procedures that may have relevance to assessing the safety of the current MRI examination.

The form also includes a question to determine if the patient had a prior injury to the eye by a metal object (e.g., metallic slivers or shavings). A "yes" response to this question alerts the MR Technologist to ask specific addition questions, and to obtain x-ray plain films if necessary.

Pregnancy must be identified prior to exposure to the MRI environment so that the risks and benefits of the MR procedure may be carefully considered by the referring physician, patient, and radiologist. The pregnant patient must give informed consent with knowledge of the possible risks to the unborn child.

An inquiry about breast feeding is included to prevent administration of MRI contrast agents to nursing mothers.

The date of the last menstrual period and presence of oral contraceptives or hormone therapy are necessary for MR procedures evaluating breast disease. These underlying situations may effect the pattern of MR contrast agent enhancement.

Questions about current medication and drug allergies are included so that the MR technologist is aware of the medical condition of the patient and is alerted to any possible drug interactions in the event that additional drugs must be administered in a life-threatening situation. Information regarding current medication is also useful to have if the patient experiences any effects during the MRI procedure. These effects may be misinterpreted as being a side effect of the MRI procedure, rather than a prescribed medication.

For the patient who requires contrast-enhanced MRI, questions related to previous experience(s) with MRI or CT contrast agents should be asked to determine whether or not special precautions are necessary.

The second page of the Pre-MRI Screening Form includes a comprehensive checklist of objects arranged, in descending order, by their relative hazard to the patient. A list of items that may produce images artifact which interfere with the interpretation of the MR images is also included. A diagram of the human body is provided for the patient to indicate the location of any object that would be potentially hazardous, or would cause an image artifact that could interfere with the interpretation of the MR images. A short list of common objects that may become projectiles or "missiles" is also included to insure that patients remove these metal objects prior to entering the MRI magnet room. Finally, a statement at the bottom of the checklist informs the patient completing the Pre-MRI Screening Form that hearing protection is required during the MR procedure.

The Pre-MRI Screening form must be completed for each patient, each and every scanning session. A previous MRI examination completed with incident does not guarantee future safe examinations. For example, the risk of injury from implanted shrapnel varies as a function of field strength. Risk or injury also varies with the orientation of the patient, anatomy being imaged, or ferromagnetic implanted object, in the magnetic field.

### ***Pre-MRI Screening References***

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