MR LINAC

MR LINAC is a magnetic resonance-guided linear accelerator that combines MRI with radiation therapy to target and treat cancers. MRI guidance allows doctors to adjust the radiation therapy in real time with better soft tissue resolution and deliver it more accurately than ever before.



If you are a candidate for treatment with MR LINAC, your medical team will develop a treatment plan for you. They will also put quality assurance procedures in place to ensure that they deliver each treatment in the exact same manner. Before treatment begins, you will undergo a planning session known as an MR LINAC simulation.

The U.S. Food and Drug Administration (FDA) approved MR LINAC for clinical use in 2017. There are dozens of machines in use worldwide, with more expected to come online in the future.

What is MR LINAC used for?

Doctors use MR LINAC to treat patients with cancer. It delivers high-energy x-rays to the region of the patient's tumor. Doctors and physicists can design these treatments in such a way that the radiation destroys the cancer cells while sparing the surrounding normal tissue.

The MR LINAC uses continuous MRI to see the soft tissue and organs moving. This allows doctors to track the tumor motion and then compensate for these movements during treatment. This is useful for tumors in the lung, prostate, pancreas, and bladder that may change position often.

MRI does a better job at showing soft tissues than x-rays or other imaging. Treatment is safer with potentially fewer side effects and allows a higher dose to reach the target. This minimizes the chance of damage to healthy organs near the tumor.

The MR LINAC has advanced software that allows your doctors to adapt your radiation treatment plan based on what they see each day.

How does the MR LINAC equipment work?

MR LINAC is a significant technological leap in cancer treatment. It combines the imaging power of MRI with a linear accelerator to deliver treatment and create images without distortion.

Magnetic resonance imaging, or MRI, obtains detailed images of organs and tissues throughout the body without the need for x-rays. Instead, MRI uses a magnetic field to create images. These images can show whether there is an injury, a disease process such as cancer, or an abnormal condition present.

For the MRI exam, the patient lies inside the MR system or scanner—typically a large donut-shaped device that is open on both ends. The powerful magnetic field aligns atomic particles called protons that exist in body tissues that contain water. The applied radio waves then interact with these protons to produce signals that a receiver picks up within the MR scanner. The signals are specially characterized using the rapidly changing magnetic fields. Computer processing creates cross-sectional images of tissues

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as “slices” that the radiologist can view in any orientation.

An MRI exam causes no pain. The electromagnetic fields produce no known tissue damage of any kind. The MR system may make loud tapping, knocking, or other noises at times during the procedure. The radiation therapist will provide earplugs to prevent problems that may be associated with noise generated by the scanner. At all times, staff will monitor you. You will be able to communicate with the radiation therapist using an intercom system or by other means.

The linear accelerator uses microwave technology (like that used for radar) to accelerate electrons in a part of the accelerator called the “wave guide.” The electrons then collide with a heavy metal target to produce high-energy x-rays. The MR LINAC shapes these high energy x-rays as they exit the machine to conform to the shape of the patient’s tumor. The customized beam is directed to the patient’s tumor. The beam is usually shaped by a multileaf collimator that is incorporated into the head of the machine. The patient lies on a moveable treatment couch. The radiation therapist uses lasers to make sure the patient is in the proper position. The treatment couch can move in many directions including up, down, right, left, in and out. The beam comes out of a part of the accelerator called a gantry, which can rotate around the patient. The machine can deliver radiation to the tumor from many angles by rotating the gantry and moving the treatment couch.

Who operates this equipment?

Your radiation oncologist prescribes the proper treatment volume and dosage. The medical physicist and the dosimetrist figure out how to deliver the prescribed dose. They also figure the amount of time it will take the accelerator to deliver that dose. Radiation therapists run the MRI scanner and the linear accelerator and give patients their daily treatments.

How is safety ensured?

The MR-LINAC is an FDA-cleared device. It has built-in safety measures to ensure that it will deliver the dose as prescribed. Medical physicists routinely check it to ensure it is working properly.

The powerful magnetic field of the MR system can attract objects made from certain metals. This may cause them to move suddenly and with great force. Therefore, great care is taken to ensure that no one brings outside objects such as ferromagnetic screwdrivers and oxygen tanks into the MR system room.

All MRI facilities have screening procedures and protocols to identify any potential hazards. These steps ensure that the radiologic technologist and radiologist know about the presence of any metallic objects. They can then take precautions as needed.

Some MRI exams involve the use of a contrast material known as gadolinium. It helps improve the information seen on the MR images. Unlike the contrast materials used in x-ray exams or computed tomography (CT) scans, a gadolinium contrast agent does not contain iodine. Therefore, it rarely causes an allergic reaction or other problem.

Before receiving a gadolinium contrast agent, tell the MRI technologist and/or radiologist if you have a history of:

- kidney disease
- kidney failure
- kidney transplant
- liver disease
- related conditions

If you are unsure about the presence of these conditions, please discuss these matters with the staff or radiologist prior to the MRI.

See the MRI Safety page (https://www.radiologyinfo.org/en/info/safety-mr) for more details.

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Before treatment, the radiation oncologist develops a plan. The radiation dosimetrist and medical physicist help with the plan. The treatment team performs quality-assurance procedures to ensure that they deliver the treatment as planned.

Quality assurance of the linear accelerator is crucial. The accelerator has several systems built in so that it will not deliver a higher dose than prescribed. Each morning before any patient undergoes treatment, the radiation therapist checks the machine. This ensures that the radiation intensity is uniform across the beam and that it is working properly. In addition, the medical physicist conducts more detailed monthly and annual checks of the accelerator.

Modern linear accelerators also have internal checking systems. These systems do not allow the machine to be turned on unless all the prescribed treatment requirements are met.

During treatment, the radiation therapist observes the patient on a closed-circuit television monitor. There is also a microphone in the treatment room so that the patient can speak with staff if needed.

Safety of the staff operating the linear accelerator is also important. The linear accelerator sits in a room with lead and concrete walls. This shields the high-energy x-rays. This means that no one outside of the room is exposed to the x-rays. The radiation therapist must turn on the accelerator from outside the treatment room. Because the accelerator only emits radiation when it is turned on, the risk of accidental exposure is extremely low.

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