

Image-Guided Radiation Therapy

This information is reviewed by a physician with expertise in the area presented and is further reviewed by committees from the American College of Radiology (ACR) and the Radiological Society of North America (RSNA), comprising physicians with expertise in several radiologic areas.

What is Image-Guided Radiation Therapy and how is it used?

Image-guided radiation therapy (IGRT) is the use of frequent imaging during a course of radiation therapy to improve the precision and accuracy of the delivery of the treatment.

In IGRT, machines that deliver radiation, such as a linear accelerator, are equipped with imaging technology so that the physician can image the tumor immediately before or even during the time radiation is delivered, while the patient is positioned on the treatment table. Using specialized computer software, these images are then compared to the images taken during simulation. Any necessary adjustments are then made to the patient's position and/or radiation beams in order to more precisely target radiation at the tumor and avoid healthy surrounding tissue.

Computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), ultrasound (US) and x-ray imaging may be used for IGRT.

IGRT is used to treat tumors in areas of the body that are prone to movement, such as the lungs (affected by breathing) and prostate gland, as well tumors located close to critical organs and tissues. It is often used in conjunction with intensity-modulated radiation therapy (IMRT), an advanced mode of high-precision radiotherapy that utilizes computer-controlled x-ray accelerators to deliver precise radiation doses to a malignant tumor or specific areas within the tumor.

Who will be involved in this procedure?

Delivery of radiation therapy requires a treatment team, including a radiation oncologist, therapeutic medical physicist, dosimetrist and radiation therapists. The radiation oncologist is a physician who evaluates the patient and determines the appropriate therapy or combination of therapies. The physician determines what area to treat and what dose to deliver. Together with the therapeutic medical physicist and the dosimetrist, the radiation oncologist determines what techniques to use to deliver the prescribed dose. The physicist and the dosimetrist then make detailed treatment calculations. Radiation therapists are specially trained technologists who acquire images and deliver the daily treatments.

What equipment is used?

In IGRT, imaging equipment is mounted on or built into the machine that delivers radiation, such as a linear accelerator. Imaging equipment may also be mounted in the treatment room. Imaging technologies used in IGRT include x-rays, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and ultrasound (US).

Who operates the equipment?

The equipment is operated by a radiation therapist, a highly trained technologist. The overall treatment plan is created and supervised by the radiation oncologist, a highly trained physician specializing in treating cancer with radiotherapy.

Is there any special preparation needed for the procedure?

Women should always inform their physician or technologist if there is any possibility that they are pregnant or if they are breastfeeding their baby. See the Safety page for more information about pregnancy, breastfeeding and imaging.

For some IGRT procedures, radiodense markers may be placed inside the body near or in the tumor to help the treatment team identify the area. Because radiodense markers are made from materials that cannot be penetrated by x-rays, they appear white on images. They are usually placed at least one week prior to the first radiation therapy treatment. The patient's skin also may be marked or tattooed with colored ink to help align and target the radiation equipment.

Otherwise, there is no specific preparation for IGRT, other than the preparation for routine radiation therapy delivery:

External Beam Therapy (EBT)

The process of external beam therapy can be divided into three parts:

- Simulation
- Treatment Planning
- Treatment Delivery

During simulation, the radiation therapist places the patient in the treatment position on a special x-ray machine or CT scanner and takes simulation x-rays. Masks, pads or other devices may be used to help the patient to hold still and in a specific position during the simulation. The radiation oncologist then locates the tumor volume and the region to be treated on these images. The dosimetrist and the radiation oncologist determine the best arrangement of radiation beams needed to treat the patient and the radiation therapist places small marks on the patients to help guide the daily treatments.

For treatment planning the dosimetrist, therapeutic medical physicist and radiation oncologist use a special computer to calculate the radiation dose that will be delivered to the patient's tumor and the surrounding normal tissue. The radiation oncologist will determine the volume of the tumor and other areas that needed to be treated and outline those on the treatment planning films. He or she will also outline normal structures that should be avoided or considered in devising the treatment plan. Together, the oncologist, dosimetrist and physicist will generate a treatment plan that delivers the appropriate dose to the tumor while minimizing dose to surrounding

normal tissues. In certain cases, this process may employ such techniques as three-dimensional conformal therapy or intensity-modulated radiation therapy.

After the simulation and treatment planning have been completed, the treatment itself can begin.

Intensity-Modulated Radiation Therapy (IMRT)

Before planning treatment, a physical examination and medical history review will be conducted. Next, there is a treatment simulation session, which includes CT scanning, from which the radiation oncologist specifies the three-dimensional shape of the tumor and normal tissues. In some cases, a treatment preparation session may be necessary to mold a special device that will help the patient maintain an exact treatment position. The dosimetrist and medical radiation physicist use the CT information to design the IMRT beams used for treatment. Several additional scanning procedures, including positron emission tomography (PET) and magnetic resonance imaging (MRI), might also be required for IMRT planning. These diagnostic images can be merged with the planning CT and help the radiation oncologist determine the precise location of the tumor target. In some cases it is necessary to insert radio dense markers into the target for more accurate positioning. Typically, IMRT sessions begin about a week after simulation. Prior to treatment, the patient's skin may be marked or tattooed with colored ink to help align and target the equipment.

Stereotactic body radiation therapy (SBRT)

Prior to the procedure, you may be given a special shampoo with which to wash your hair. You will be asked not to eat or drink anything after midnight on the night before your treatment. You should ask your physician what to do about taking any normal medications on the day of your treatment and bring those medications with you to the procedure. You should also tell your physician if any of the following apply to you:

- You are taking medications by mouth or insulin to control diabetes.
- You are allergic to intravenous contrast material, shellfish, or iodine.
- You have a pacemaker, artificial heart valve, defibrillator, brain aneurysm clips, implanted pumps or chemotherapy ports, neurostimulators, eye or ear implants, stents, coils or filters.
- You suffer from claustrophobia.

Stereotactic radiosurgery is usually performed on an outpatient basis. However, be prepared to spend up to 16

hours in the hospital. You will need to have a family member or other support person accompany you, remain with you at the treatment facility, and drive you home afterward.

On treatment day, you will be asked to remove all jewelry, makeup (including nail polish) hairpieces, contact lenses, eyeglasses and dentures. You will be asked to change into a gown for your procedure. An intravenous (IV) line may be inserted into your arm for any necessary medications. You may receive medications to help you relax and to prevent dehydration.

How is the procedure performed?

At the beginning of each radiation therapy session, the patient is carefully positioned guided by the marks on the skin defining the treatment area. Devices may be used to help the patient maintain the proper position. Images are then taken using imaging equipment that is built into the radiation delivery machine or mounted in the treatment room.

The physician then reviews the images and compares them to the images taken during simulation. The patient may be repositioned and additional imaging may be performed. After any necessary adjustments are made to the treatment plan and patient positioning, radiation therapy is then delivered.

The image-guidance process may add up to five minutes to each radiation therapy session.

What will I feel during and after this procedure?

Imaging performed prior to or during radiation therapy sessions is painless.

During the radiation therapy session, you may see or hear equipment moving around you during the imaging procedure. Patients may sometimes smell an odd smell during treatment that is caused by the ozone produced by the linear accelerator. Some patients may also see a colored light when they receive their treatment; this event is especially true for patients having their brain treated.

Side effects of radiation treatment include problems that occur as a result of the treatment itself as well as from radiation damage to healthy cells in the treatment area.

The number and severity of side effects you experience will depend on the type of radiation and dosage you receive and the part of your body being treated. You should talk to your doctor and nurse about any side effects you experience so they can help you manage them.

Radiation therapy can cause early and late side effects. Early side effects occur during or immediately after treatment and are typically gone within a few weeks. Common early side effects of radiation therapy include tiredness or fatigue and skin problems. Skin in the treatment area may become more sensitive, red, irritated, or swollen. Other skin changes include dryness, itching, peeling and blistering.

Depending on the area being treated, other early side effects may include:

- hair loss in the treatment area
- mouth problems and difficulty swallowing
- eating and digestion problems
- diarrhea
- nausea and vomiting
- headaches
- soreness and swelling in the treatment area
- urinary and bladder changes

Late side effects, which are rare, occur months or years following treatment and are often permanent. They include:

- brain changes
- spinal cord changes
- lung changes
- kidney changes
- colon and rectal changes
- infertility
- joint changes
- lymphedema
- mouth changes
- secondary cancer

There is a slight risk of developing cancer from radiation therapy. Following radiation treatment for cancer, you should be checked on a regular basis by your radiation oncologist for recurring and new cancers.

Using techniques such as IGRT, imaging specialists are maximizing the cancer-destroying capabilities of radiation treatment while minimizing its effect on healthy tissues and organs and the side effects of the treatment itself.

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