# Stereotactic Radiosurgery & Radiotherapy of the Head

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reviewed by > John Breneman, MD and Ron Warnick, MD

*The following is an advanced-level, step-by-step description of stereotactic radiosurgery (SRS) and fractionated stereotactic radiotherapy (FSR) procedures for the head performed in a linear accelerator (LINAC). For basic-level information, see Introduction to Radiation Therapy*

## Stereotactic Radiosurgery (SRS)

Stereotactic radiosurgery is a form of external beam radiation that delivers a high-dose during a single session to shrink or destroy tumors and vascular malformations of the body (Fig. 1). Because a single radiosurgery dose is more damaging than multiple fractionated radiotherapy doses, the target area must be precisely located and completely immobilized with a stereotactic head frame. Any tumor, lesion or malformation to be treated with radiation is called a target. Patients spend the day at the treatment center while the target is located stereotactically, a treatment plan is developed, and radiation is delivered.

## Fractionated Stereotactic Radiotherapy (FSR)

Radiosurgery treatments given over multiple visits are called fractionated stereotactic radiotherapy (FSR). Until recently, fractionation was not possible using stereotactic techniques because there was no way to keep the rigid frame in place after the first treatment session. Repositionable masks along with laser, x-ray and infrared positioners ensure treatment accuracy, making multiple radiosurgery sessions possible. FSR offers the precision of stereotaxy for those who have lesions near critical structures (the brain stem, optic and acoustic nerves) that cannot tolerate high doses. Patients spend the first day at the treatment center while the target is located stereotactically and a treatment plan is developed. They will return daily for several weeks to receive fractions of the complete dose.

## LINAC vs. Gamma Knife

Two kinds of machines can deliver radiosurgery – a linear accelerator (LINAC) and Gamma Knife. The machines have many similarities, but also important differences. LINAC machines use a single intense radiation beam that is delivered in multiple arcs around the target. They can perform radiosurgery on small and large tumors and can fractionate these treatments over several days. In contrast, Gamma Knife does not move around you. The target is placed exactly in the center of 201 individual converging beams. Its ability to treat large targets is limited, and it does not allow fractionated treatments.


**Figure 1.** Before radiosurgery, a treatment plan is developed to shape the radiation beam to the exact shape of the arteriovenous malform-ation (AVM) and minimize exposure to normal brain tissue. The colored rings represent the radiation dose level. Over several months to years after radiosurgery, the AVM vessels close off, effectively removing the lesion.

## Am I a candidate?

You may be a candidate for SRS or FSR if you have a:

- Benign tumor: acoustic neuroma, pituitary adenoma, meningioma, craniopharyngioma, glomus
- Malignant tumor: glioma, glioblastoma, astrocytoma, lymphoma
- Metastatic tumor
- Arteriovenous malformation (AVM)
- Cavernoma
- Trigeminal neuralgia

SRS and FSR may be used alone or with other treatments such as surgery, chemotherapy or immunotherapy. It can be used when a tumor or malformation is first diagnosed or has recurred after previous treatment; or it can be used as a supplement, commonly called boost therapy, to other treatments.

Once your condition has been diagnosed, your doctor will discuss all treatment options and may recommend a consultation with a radiation oncologist. The neurosurgeon and radiation oncologist will work together to choose the best type of radiation for your particular tumor or lesion, explain the treatment process, and describe some possible side effects. Once you have decided to proceed with treatment, you will need to sign a consent form. The doctor may also send you for a special MRI scan for use during radiation treatment planning.

## What happens before treatment?

Because sedation is used during placement of a stereotactic head frame, no food or drink is permitted past midnight the night before radiosurgery. If you are having FSR with a repositionable mask, there are no restrictions. Come to the hospital or outpatient center the morning of the procedure and check in with the receptionist when you arrive. Dress comfortably and bring a book or something else to keep you busy during the waiting periods. You may also bring a friend or a relative with you for company. If you are having SRS, please make arrangements for transportation home as you might feel tired after the treatment; driving is not recommended.

The nurse or radiation therapist will escort you to a patient holding room, where you may need to change into a gown. An intravenous (IV) line is placed in your arm.

## What Happens During Treatment

### Step 1. Attach stereotactic frame

For stereotactic radiosurgery (SRS), a stereotactic frame is attached to your head with pins. While you are seated, the frame is temporarily positioned with Velcro straps. The four pin sites are cleaned and injected with local anesthesia while you receive conscious sedation to minimize discomfort. You may feel some pressure as the pins are tightened (Fig. 2). Placement of the head frame takes about 30 minutes.

For fractionated stereotactic radiotherapy (FSR), a repositionable stereotactic mask is custom-made to fit your face exactly and is used during each treatment session. First, a cream is applied to your face. Next, you will lie with your head on a cradle of mesh stretched between a U-shaped frame (Fig. 3). Thermoplastic mesh is dipped into a warm water bath, making the mesh very flexible. The mesh is placed over your forehead and nose and gently molded to conform to your face (you can easily breathe). In some cases, the mesh may extend over the chin. The mesh dries quickly. Creation of the mask takes about 30 minutes.

**Figure 2.** A stereotactic frame is attached to your head with four pins. The frame is worn during CT scanning and treatment, where it is secured to the table to hold the head still.

**Figure 3.** A repositionable stereotactic mask consists of thermoplastic mesh custom-made to fit the contours of your face. The front and back pieces of mesh are secured to a U-shaped frame, which attaches to the treatment table to hold the head still.

**Figure 4.** A localizing cage, called the bird cage, is placed on the frame or mask prior to CT scanning. The rods of the frame are seen on the CT scan and help pinpoint the exact coordinates of the brain tumor or malformation.

### Step 2. CT or MRI localization

Next you will have an imaging scan using either computerized tomography (CT) or magnetic resonance imaging (MRI). A device, which looks like a birdcage, may be placed over top the head frame or mask (Fig. 4). The rods of the bird cage show up on the scan and help pinpoint the exact three-dimensional coordinates of the target within the brain. After the scan, the cage is removed but the frame remains in place.

Typically, patients receiving FSR go home after the localization scan. The doctors continue with step 3 (treatment planning), and the patient returns within a week or so to begin treatment. In contrast, SRS patients are taken to a private room and given a light breakfast while they wait for the treatment plan to be determined so that radiation can be delivered on the same day.

### Step 3. Treatment planning

Information about the target's location, volume, and proximity to critical structures is gathered by the CT scan and transferred into the treatment planning computer system. In some cases MRI images also are sent electronically to the system. The software uses the CT or MRI images to form a 3D view of your anatomy and the target. Using the software, the team (radiation oncologist, surgeon and physicist) determine the radiation prescription:

- appropriate radiation dose
- number and angle of treatment arcs
- size and shape of the beams to exactly match your tumor or target

It is crucial that the dose be delivered only to the target area. By using numerous beams, radiation of normal tissue is minimized. All beams meet at a single point, where the target is located. At the center, the single beams add up to a very high dose of radiation.

### Step 4. Position the patient

Once the LINAC is calibrated and prepared for your specific treatment plan, you will lie on the treatment table. The stereotactic head frame or repositionable mask will be secured to the table. Alignment lasers and localizing x-rays help the radiation therapist position you correctly (Fig. 5). Stereoscopic x-rays are taken and compared to the treatment plan. Any misalignments are detected and corrected by a computer-controlled, motorized tabletop before treatment.

### Step 5. Treatment

Once exact positioning is confirmed, the therapist leaves the room and operates the LINAC machine from the control room. The treatment team watches you through video monitors and speaks to you over an intercom. The LINAC and treatment table periodically moves to deliver radiation beams from one or more directions.

The LINAC machine is large and makes noises as it moves around your body. Its size and motion may be intimidating at first. It may pass close to your body, but it will not touch you. Treatment may take 30-60 minutes or longer, depending on the number of targets.

## What happens after treatment?

### Step 6. Remove stereotactic frame

After treatment the radiation therapist releases the stereotactic frame or mask from the table. If you received SRS, the nurse removes the stereotactic frame. You may have oozing from the pins sites and have a mild headache. You may then gather your belongings and go home.

If you received FSR, the repositionable mask is removed and stored at the center for your next treatment session. You will return each day at your scheduled time to repeat steps 4 through 6 until all fractions of the complete dose are delivered.

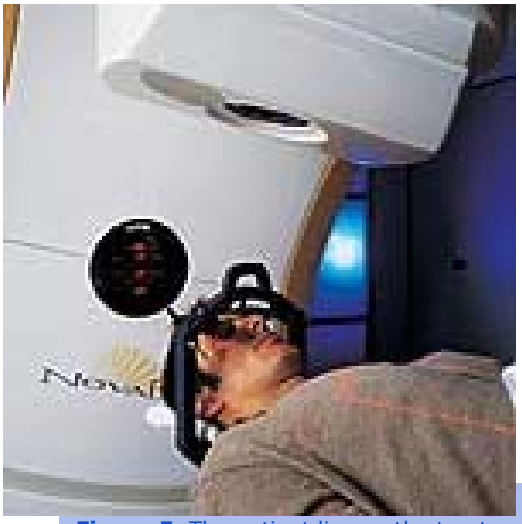

**Figure 5.** The patient lies on the treatment table while the LINAC rotates, aiming the radiation beams at the tumor. The stereotactic frame attached to the patient's head is secured to the table - precisely positioning the target in the treatment field.

## Care of pin sites (SRS only)

**Discomfort**

1. If you have discomfort or tenderness around the pin sites, Tylenol may help.

**Incision Care**

2. Steri-strips or bandaids may cover the pin sites. Remove them the next day.
3. Swelling may occur around the pin sites several days later. Keep your head elevated and apply an ice pack to the area.

**When to Call Your Doctor**

4. Please contact our office at 475-7777 if your temperature exceeds 101 °F.
5. Inspect the pin sites daily. Call if they show any of the following:
   - Drainage
   - Any separation
   - Any sign of infection, that is, increased redness, swelling, or pain

## What are the results?

Following SRS or FSR treatment, CT, MRI or angiography scans will be taken periodically to look for signs of response. Several months may pass before the effects of treatment are visible.

**For AVMs,** the goal is to thicken the vessel walls and create clots that will close off the blood supply to the AVM. It may take up to 3 years for an AVM to close off completely. Results are related to the size and flow rate of the AVM. Small AVMs (<3 cm) have

an 80% success rate. Larger AVMs (>5cm) may require multiple radiosurgery treatments spaced several years apart.

**For acoustic neuromas, meningiomas or pituitary adenomas,** the goal is to shrink or stop the tumor's growth. About 40% of patients with an acoustic neuroma or meningioma show tumor shrinkage after radiosurgery, while about 50% of tumors remain the same. Fewer than 10% of these tumors continue to grow. Facial nerve and/or trigeminal nerve problems develop in about 3% of acoustic patients.

**For metastatic tumors,** the goal of shrinking or stopping the tumor's growth is achieved in the majority of patients.

**For trigeminal neuralgia,** the goal is to control pain. Excellent or good pain relief occurs in the majority of patients. Pain relief may not occur immediately but rather gradually over six months to a year. Facial numbness may develop in 10% of patients.

**For malignant tumors,** results vary depending on the size, location and type of tumor. Talk to your doctor about your specific prognosis.

## What are the risks?

Side effects vary depending on the tumor type, total radiation dose, size of the fractions, length of therapy, and amount of healthy tissue in the target area. Some side effects are temporary and some are permanent. Generally, patients may experience fatigue, skin irritation around the target area, and hair loss.

On rare occasions, the radiation dose can cause a buildup of dead tumor tissue, called radiation necrosis, several weeks to months after treatment. Dead or necrotic tissue can become toxic to surrounding normal tissue, and swelling may occur. Brain swelling causes headaches, seizures and confusion. Treatment for radiation necrosis may include steroid medication, hyperbaric oxygen treatments or surgical removal.

## Sources & links

If you have more questions, please contact Precision Radiotherapy at 513-475-7777. Additional information is available on the web at www.PrecisionRadiotherapy.com.

### Links

National Cancer Institute
www.cancer.gov
International Radiosurgery Association
www.irsa.org
American Brain Tumor Association
www.abta.org

www.radiologyinfo.org

www.oncologychannel.com

## Glossary

**acoustic neuroma:** a benign, slow growing tumor that forms on the sheath of the eighth cranial nerve. This tumor can cause hearing loss, balance problems, and facial palsy.
**arteriovenous malformation (AVM)**: abnormal tangle of blood vessels where arteries connect directly to veins without an intervening capillary bed.
**benign:** not cancerous.
**cavernoma:** abnormal cluster of enlarged capillaries with no significant feeding arteries or veins.
**chemotherapy:** treatment with toxic chemicals (e.g., anticancer drugs).
**fractionated:** delivering the radiation dose over multiple sessions.
**lesion:** a general term that refers to any change in tissue, such as tumor, blood, malformation, infection or scar tissue.
**linear accelerator:** a machine that creates a high-energy radiation beam, using electricity to form a stream of fast-moving subatomic particles; also called a LINAC.
**malignant:** cancerous.
**meningioma:** a tumor that grows from the meninges, the membrane that surrounds the brain and spinal cord.
**metastatic:** cancerous tumor that has spread from its original source.
**stereotactic**: a precise method for locating structures within the body by the use of 3-dimensional coordinates.
**target**: area where the radiation beams are aimed; usually a tumor, malformation or other abnormality of the body.
**trigeminal neuralgia:** a painful disorder of the fifth cranial nerve (trigeminal nerve). Irritation of this nerve can cause intense pain that usually affects one side of the face.

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attn: Joe Fodor, 7710 University Court, West Chester, OH 45067, or call 513-475-7777.