Gamma Knife Stereotactic Radiosurgery (face mask)

Overview

Gamma Knife radiosurgery uses high-energy rays to destroy tumors and other diseases. Beams of radiation are aimed at the brain by a machine outside your body. Hundreds of low-dose beams come together at a single point to kill all the cells in the target area while avoiding damage to nearby healthy cells. When a large tumor is being treated, radiation is given in 5 treatments using a mask system.

What is stereotactic radiosurgery?

Radiation damages the DNA inside cells, making them unable to divide and grow. The benefits of radiation are not immediate but occur with time. Aggressive tumors, whose cells divide rapidly, tend to respond quickly to radiation. Over time, the abnormal cells die and the tumor may shrink. Benign tumors, whose cells divide slowly, may take several months to a year to show an effect.

Pinpoint accuracy is critical so that the lethal dose is applied only to the target itself and not to surrounding healthy tissue or critical structures (Fig. 1). To achieve the razor-sharp precision, computer image-guided technology is used to plan and carry out the procedure. The method of targeting an object in three dimensions is called stereotaxis.

When a tumor larger than 3 centimeters in diameter is being treated, radiosurgery is given in 5 daily sessions. Delivering a fraction of the total radiation dose allows normal cells time to repair themselves between treatments and may reduce side effects. Your doctors may recommend radiosurgery as a stand-alone treatment or in combination with surgery, chemotherapy, or immunotherapy. If you first undergo removal of a tumor, your doctor may prescribe radiation to stop the growth of microscopic tumor cells that remain after surgery.

Gamma Knife technology allows your physician team to treat brain tumors of any size (up to 6 centimeters) or shape, and in any location, with accuracy to .3 millimeters. Tumors that are close to critical brain structures can be safely targeted.

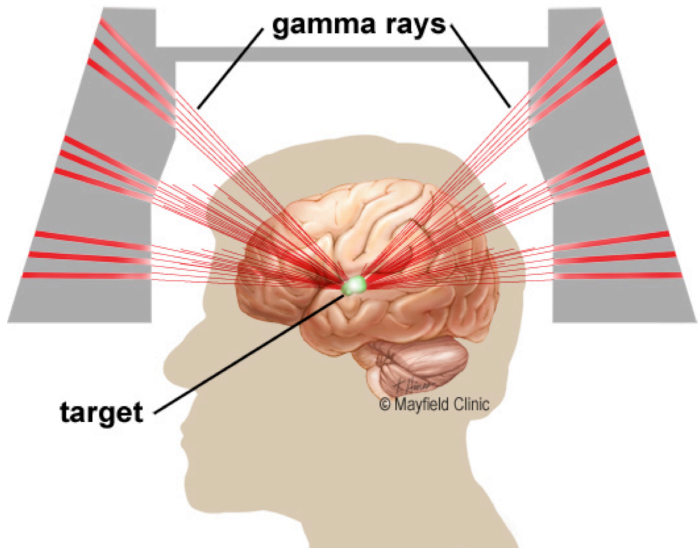

Figure 1. Gamma Knife utilizes 192 low-dose beams of radiation that intersect at the tumor to produce a high dose while minimizing exposure to nearby healthy brain.

The goals of Gamma Knife radiosurgery are to:

1. Precisely locate the target (tumor)
2. Hold the target still
3. Accurately aim the 192 radiation beams at the target
4. Deliver radiation at the specified dose that conforms to the shape of the tumor

Who is a candidate?

You may undergo 5 sessions of radiosurgery if you have a:

- Metastatic tumor or tumors that have spread to the brain from the lung, breast, or skin (melanoma)
- Benign primary brain tumor (meningioma)
- Glioblastoma (GBM), an aggressive brain cancer

Who performs the procedure?

The radiosurgery team consists of a neurosurgeon, radiation oncologist, critical care nurse, medical physicist, and radiation therapist. The medical physicist and radiation therapist will customize the mask. The neurosurgeon and radiation oncologist are responsible for determining the correct target and radiation dose, and for approving the treatment plan. The medical physicist is involved in treatment planning and setting up the equipment. The radiation therapist positions the patient in the machine and monitors the treatment under the supervision of the physicians and medical physicist. The critical care nurse coordinates the treatments and manages medications.

What happens before treatment?

Consultation

Your first appointment is a radiosurgery consultation with a neurosurgeon or radiation oncologist. Your doctor will perform a physical exam and confirm your diagnosis based on the imaging studies (CT, MRI) and pathology reports. Your doctor will discuss the best type of radiation treatment for your particular tumor or lesion, explain the treatment process, and discuss the potential benefits and possible side effects. Once you have decided to proceed with treatment, you will sign consent forms. Your doctor will also prescribe steroids (e.g., dexamethasone) and anti-seizure medication (e.g., Keppra).

What happens during treatment?

On the days of treatment, arrive at the center and check in with the receptionist. You may bring a relative or friend with you for company.

Step 1: preparing the mask

Prior to the day of your first treatment, a stereotactic mask is custom-fit to your face. It will be used during imaging and treatment to hold your head perfectly still. You will lie with your head secured in an appliance that is attached to the treatment bed. A sheet of plastic mesh is heated to a warm temperature in an oven and then placed across your face, covering your forehead, eyes, cheeks, and chin. Your nose will be exposed, enabling you to breathe easily (Fig. 2). Creation of the mask takes about 15 minutes.

Step 2: imaging

Even though you have had brain imaging done before, you will need to have it done again with the mask so that the exact location, size, and shape of the target can be determined. A reflective marker is placed on your nose to provide reference points on images for the treatment plan. A CT scan is taken by a scanner inside the Gamma Knife machine. You then will undergo an MRI scan in the radiology department.

Step 3: treatment planning

Planning for your treatment is complex and vitally important. It is a team effort that can take from 1 to 3 hours. Information about the tumor's location, size, and closeness to critical structures is gathered by the CT and MRI scans, which are fused to provide 3-dimensional mapping of your brain. Advanced computer software creates a 3D view of

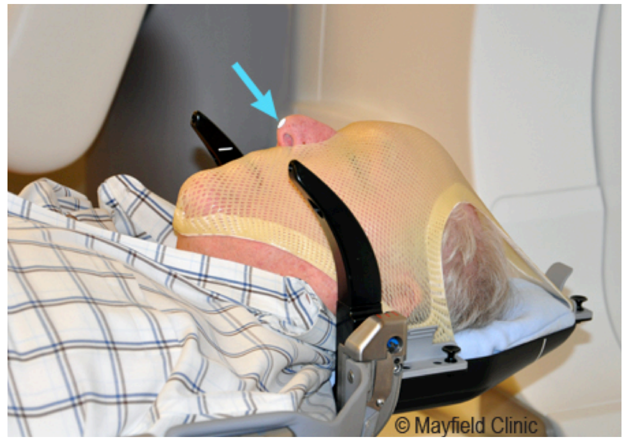

Figure 2. A thermoplastic mask is custom-fit to the contours of your face. A reflective marker on the nose (arrow) is monitored by an infrared camera system to detect any movements.

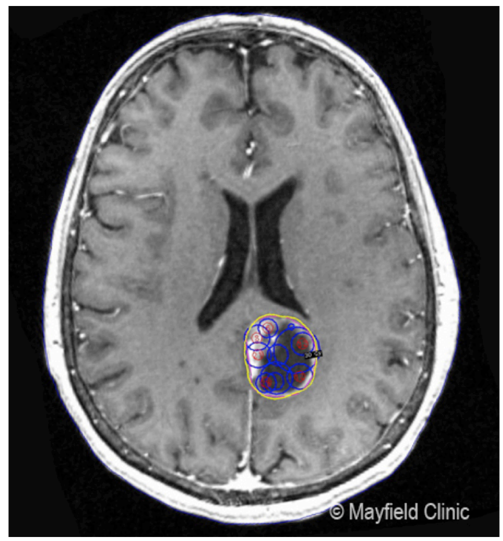

Figure 3. The computer creates a 3D view of your anatomy from the MRI/CT scans. The physicians determine the number and size of the radiation beams, as well as the radiation dose.

Figure 4. The facemask is secured to the table and holds the patient's head perfectly still in the treatment field.

Figure 5. The table moves your head into the machine. Radiation is delivered through 192 openings in the Gamma Knife machine.

your anatomy and the tumor (Fig. 3). Using the software, the neurosurgeon, radiation oncologist, and medical physicist work as a team to determine the:

- appropriate target(s)
- contours of the target(s)
- radiation dose
- number of individual treatment beams, their diameter, and how long they will deliver radiation to the target(s)

Each individual beam is too weak to damage the healthy brain as it passes through on its way to the target. But at the focal point where all the beams merge, the energy dose is powerful and capable of damaging the tumor cells. This high-dose radiation corresponds to the shape of your tumor or tumors.

Step 4: position the patient
You will lie on the treatment table, and the mask will be placed over your face and secured to the table (Fig. 4). Another CT scan will be performed while you lie on the treatment table, registering your exact position in the Gamma Knife. This new CT scan is then fused with the previous CT and MRI scans in your treatment plan. A small reflective marker on your nose sends infrared beams back to the computer system, which monitors any potential movements. If you move during treatment – if you fall asleep and suddenly awaken, for example – the radiation stops. If this happens, another CT scan is performed to re-establish your positioning, and the treatment resumes.

Step 5: deliver the radiation
The therapist leaves the room and operates the machine from the control room. The team watches you through video monitors and speaks to you over an intercom. The treatment table moves every so often to deliver radiation beams from one or more directions (Fig. 5).

You will hear some mechanical sounds as the 192 radiation sources move into position. Your treatment will be completely painless. The treatment table will move your head into different positions through small, preprogrammed movements. You do not have to hold your breath; just breathe normally. Each of your treatments will last anywhere from 15 minutes to 1 hour.

What happens after treatment?
After treatment, the therapist releases the mask and helps you off the treatment table. The mask is then stored at the center for your next session. You will return each day at your scheduled time until all fractions of the treatment plan are delivered. You will continue taking steroids and anti-seizure medications throughout treatment and for 2-3 weeks thereafter.

What are the risks?
Side effects of radiation vary, depending on the tumor type, dose delivered to the tumor, number of fractions, and amount of healthy tissue in the target area. Some side effects are temporary and some may be permanent. Ask your doctor about specific side effects that you may experience. General side effects may include:

Swelling (edema)
Radiation causes tumor cells to die. The body's natural response to cell death or injury is swelling. Edema is extra fluid, or swelling, within the tissues of the brain. If brain swelling occurs, it can cause headaches, weakness, seizures, confusion, or speech difficulty. It may also worsen the symptoms that were present before treatment. If you start to feel uncomfortable with headaches or any other symptoms, call your neurosurgeon or radiation oncologist. Steroid medication (dexamethasone) may be given to reduce brain swelling and fluid

within the tumor. Steroids should always be taken with food to protect your stomach and prevent nausea. Steroids can also affect the normal bacteria in your mouth and cause a yeast infection called thrush, which appears as whitish patches on the tongue. Do not abruptly stop taking steroids. A tapering schedule is required to avoid withdrawal.

Radiation necrosis
In some cases, radiosurgery may cause the center of the tumor to become necrotic (dead). Radiation necrosis can happen anytime, but it most often occurs 6 to 12 months after radiosurgery. This dying tissue can become toxic to surrounding normal tissue, and swelling may occur.
Radiation necrosis may look similar to tumor regrowth on an MRI scan. Specialized tests such as MR spectroscopy/perfusion may help differentiate between necrosis and tumor. Treatment for radiation necrosis may include:

- Medicines that reduce inflammation, such as 5-LOXIN (Boswellia serrata).
- A drug called bevacizumab (Avastin) may be given if other treatments are not effective.
- Hyperbaric oxygen therapy (treatment in an oxygen chamber) may be prescribed to help damaged brain tissue heal.
- In some cases, surgery may be needed to remove the necrotic tissue.

What are the results?

After radiosurgery, MRI scans will be taken periodically so that your doctors can look for signs of response. Several months may pass before the effects of treatment are visible. Some tumors or lesions may be completely eliminated with radiation. For others, the goal is to stop or halt the growth. In some cases, the tumor is considered "controlled," even if it does not shrink.

For benign tumors, the goal is to stop or control the tumor's growth. About 60% of patients with a meningioma show tumor shrinkage after radiosurgery, while about 30% of tumors remain the same (Fig. 6). Fewer than 10% of these tumors continue to grow.

For metastatic tumors, the goal of shrinking or stopping the tumor's growth is achieved in 80-90% of patients (Fig. 7).

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

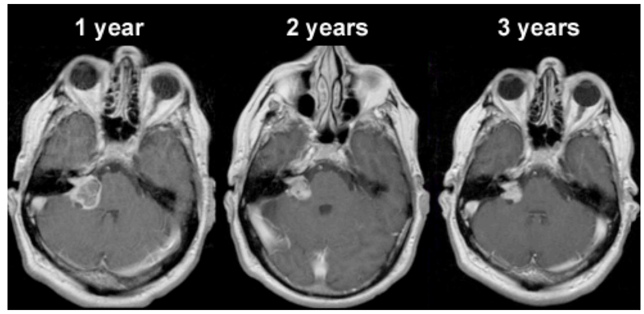

Figure 6. Following radiation, slow-growing (benign) tumors shrink gradually over time.

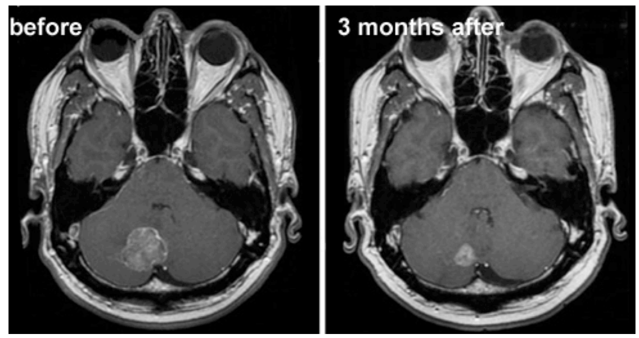

Figure 7. Fast-growing malignant tumors like metastatic lung cancer shrink rapidly after radiation.

Sources & links

If you have questions, please contact Mayfield Brain & Spine at 513-221-1100.

Links
www.cancer.gov
www.irsa.org
www.abta.org
www.elekta.com/patients/

Glossary

benign: not cancerous.
malignant: cancerous.
metastatic: a cancerous tumor that has spread from its original source (e.g., lung, breast).
stereotactic: a precise method for locating structures within the body through the use of 3-dimensional coordinates.
target: the area where radiation beams are aimed; usually a tumor, malformation, or lesion.

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