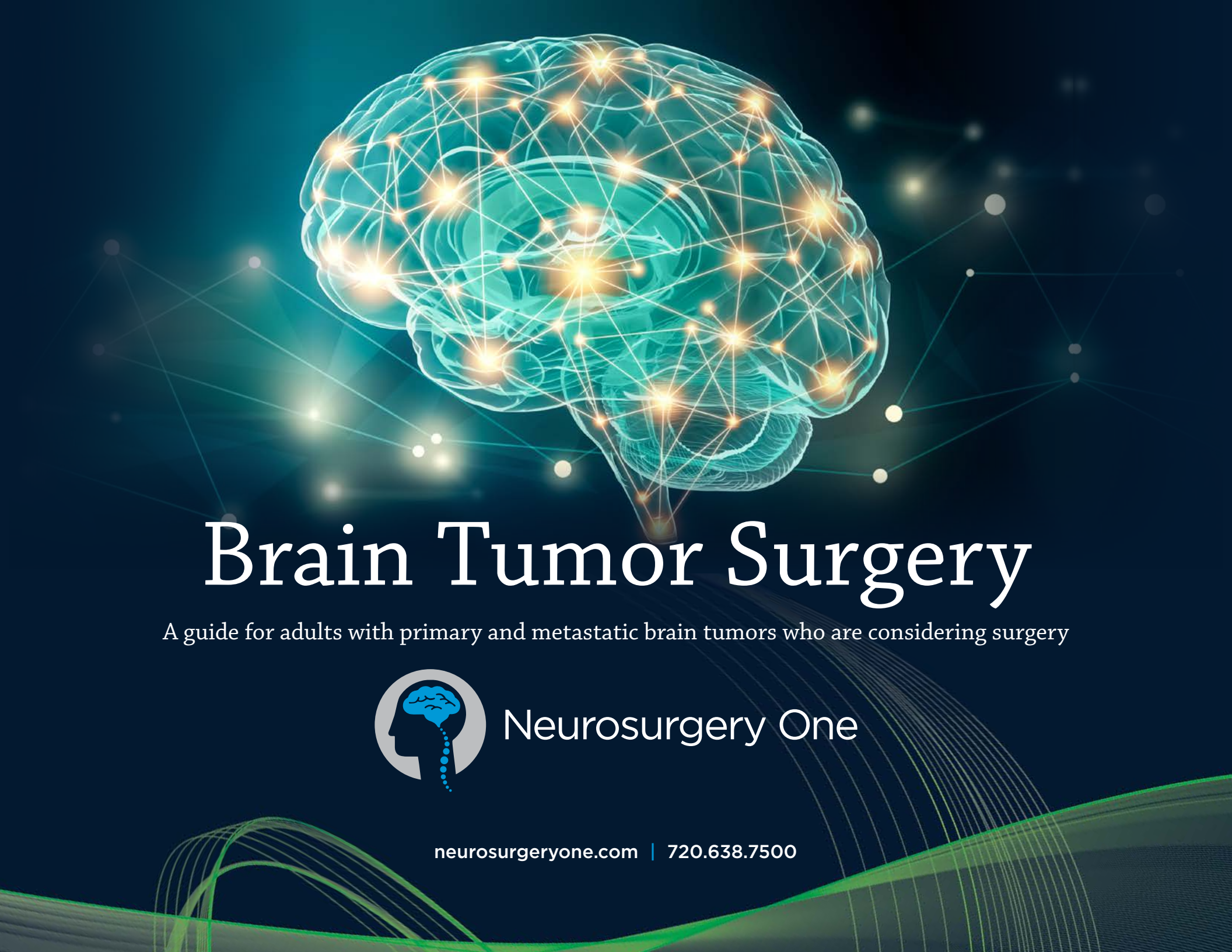

Brain Tumor Surgery

A guide for adults with primary and metastatic brain tumors who are considering surgery

Neurosurgery One

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TABLE OF CONTENTS

Considering Brain Tumor Surgery

The diagnosis of a brain tumor can be frightening and the thought of surgery even more so. We understand that and we hope to relieve some of your anxiety in this guide by providing you with information about how brain tumor surgery is planned, the types of surgery, and what you can expect.

First off, it is important to know that not all brain tumors need treatment and that there are alternatives to traditional surgery. If your brain tumor is not cancerous and is not causing any symptoms, we most likely will recommend a wait-and-watch approach. If the tumor shows signs of growing, then we may talk with you about treatment options.

At Neurosurgery One, we use the latest in diagnostic testing to analyze brain tumors and determine what treatment approach provides the most benefit with the least amount of side effects. Depending on the type, location, and size of your tumor as well as your symptoms, we may recommend surgery.

For some patients, radiation or chemotherapy may be better suited than surgery. For other patients, surgery combined with radiation or chemotherapy might be most beneficial.

When we recommend surgery, our goal is to always provide you with the best outcome and the highest quality of life. To do this, we are always assessing how to treat the tumor without impairing any vital cognitive or functional abilities.

Tumors that have traditionally been considered "inoperable" may now benefit from tumor surgery, thanks to advancements in imaging, brain mapping, and awake craniotomy.

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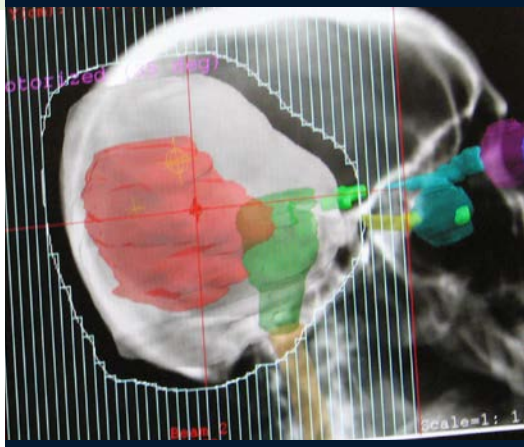
Assessing Treatment Options

With nearly 30 years of experience treating brain tumors, Neurosurgery One has the expertise to address the many types of brain tumors. We have developed a rigorous approach to developing treatment plans for tumors based on the latest research and technology. Here are the steps you can expect:

1. Your neurosurgeon who is specially trained in treating brain tumors will meet with you to review your health history, symptoms, and goals. This is a great time to tell us your expectations for your care.
2. Next, we will complete a neurological exam to assess your motor skills, vision, and behavior, all of which help provide more insights into treatment options.
3. Then we conduct imaging tests, which may include MRI, CT, functional MRI (fMRI), PET, fiber tractography. If a metastatic tumor is suspected, our team may recommend a CT or PET to determine where the cancer originated if that has not already been determined. At Neurosurgery One, we work closely with your oncology team to develop a treatment plan for metastatic tumors and malignant primary brain tumors.
4. A biopsy may be taken of the tumor to help further determine its type and whether or not it's cancerous.
5. Once the type, location, and size of your brain tumor are determined, our brain tumor team will collaborate on the most effective treatment plan. Your neurosurgeon will discuss the options and recommendation with you, along with the benefits and risks of the surgery, the research supporting the surgery option, what you can expect as a result of your surgery, and any alternative approaches.



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Brain Tumor Imaging

Neurosurgeons use a variety of imaging tests during diagnosis and treatment of brain tumors. At Neurosurgery One, we use the following tests to better understand your tumor and treatment options.

> **Magnetic resonance imaging (MRI)** utilizes radio waves and magnets to create detailed images of the brain and other organs. MRI is noninvasive and can be used to diagnose brain tumors.

> **Functional magnetic resonance imaging (fMRI)** is a noninvasive way to measure brain activity by using MRI to detect areas of blood flow in the brain. fMRI is particularly helpful in assessing the tumor's impact on functional areas of the brain and is often utilized during tumor surgery.

> **Computerized tomography (CT)** is a noninvasive scan that uses X-rays to attain cross-sectional images of the brain. CT scans also can help identify cancer that may have spread from another area of the body or originated in the brain.

> **Fiber tractography** is a 3-D modeling technique that utilizes MRI and computer-based diffusion MRI to map the white matter in the brain. We use this noninvasive tool to plan your surgery.

> **Positron emission tomography (PET)** detects how organs and tissues are functioning. PET scans are imaging tests that work by injecting a small amount of low-dose radioactive material into a vein. PET is most effective in detecting cancer in other parts of the body.

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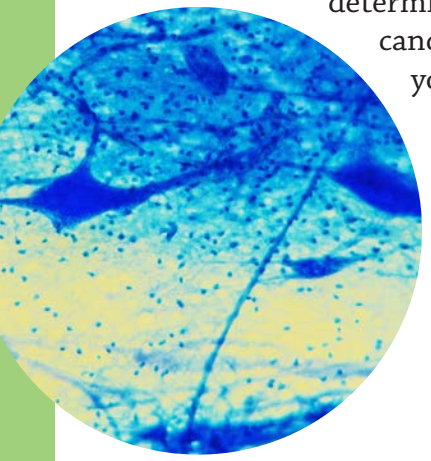
Tumor Biopsy

In addition to imaging, your neurosurgeon may recommend performing a biopsy to obtain a sample of the tumor. **A biopsy is often performed to determine the type of tumor and whether or not it is cancerous.** Biopsies are generally recommended for tumors that are deep within the brain.

A biopsy may be performed before tumor removal surgery or at the time of the surgery. If the tumor is cancerous, the biopsy can help determine the type and grade of cancer. This information helps your neurosurgeon plan your tumor treatment — even if it is being performed at the same time. Biopsies are less invasive than craniotomies and have lower complication rates. Typically, patients only spend one night in the hospital after a biopsy.



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Types of Brain Tumor Surgery

Our neurosurgeons provide precision tumor surgery that best treats your particular tumor and situation, including:

> **Craniotomy** is the most common type of surgery for brain tumors. During a craniotomy, your neurosurgeon will remove a portion of your skull to access and remove as much of the tumor as possible. Patients are typically asleep during this procedure.

> **Awake craniotomy** allows for surgery on tumors that affect eloquent regions of the brain, which are also known as functional areas of the brain like those that control speech, vision, or movement.

In addition to surgery, your neurosurgeon will consider other treatment options. We discuss these on Page 9.

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Craniotomy Surgery

Craniotomy is the most common type of surgery to treat brain tumors. Most craniotomies are performed while the patient is asleep. Resections can be full or partial, depending on whether the entire tumor is removed or just a portion of the tumor. Based on the consistency of the tumor, your neurosurgeon might remove the tumor with a scalpel or scissors, laser ablation, suction, or ultrasonic aspirator.

During the surgery, Neurosurgery One surgeons may use technology called fiber tractography to map the brain to better remove deep-seated tumors, such as those near the thalamus and basal ganglia. This specialized MRI mapping allows us to perform craniotomies to remove tumors that were often deemed inoperable in the past.

BENEFITS OF CRANIOTOMY

- Craniotomies are used to treat all types of brain tumors, both benign (noncancerous) and malignant (cancerous), including primary brain tumors and metastatic brain tumors.
- Craniotomy can result in full or partial removal of the tumor, which can greatly improve a patient's prognosis and reduce tumor symptoms. Patients typically spend 1-2 days in the ICU after surgery and then 2-4 days recovering in the hospital before going home. In some occasions, tumor surgery patients may need inpatient rehabilitation before going home.
- Your outcome is dependent on many factors, primarily the size and location of your brain tumor(s). Patients whose tumors are compact, easily accessible, and not close to any vital areas often recover fully and don't experience any further symptoms. Other patients, including those who have malignant brain tumors may require additional treatments, including possible further surgery if tumors regrow or return.

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Awake Craniotomy for Intrinsic Brain Tumors

Recently, neurosurgeons — including Neurosurgery One — have begun performing craniotomies with patients awake. Awake craniotomy has been used in the U.S. since the 1980s during epilepsy surgery and in recent years has become an effective procedure for intrinsic brain tumors, or tumors inside the brain.

Neurosurgery One neurosurgeons use technology called brain mapping to pinpoint the location of lesions in the brain that are causing symptoms. During the surgery, the neurosurgeon will test areas such as speech or motor function to minimize impacting functional capabilities.

Some of the research results supporting the use of awake craniotomy include:

- Intraoperative mapping for high-grade gliomas during awake craniotomy show better outcomes for patients, including more tumor removal; lower complication rates; and greater postoperative survival rate as compared to traditional asleep craniotomy.[1]
- When compared to traditional craniotomy for gliomas, awake craniotomy had a higher likelihood of removing the entire tumor.[2]
- Awake craniotomy has been found to have similar complication rates as those of traditional sleep craniotomy.[3]
- Hospital costs and length of hospital stays have been shown to be lower with awake craniotomy when compared to traditional surgery under general anesthesia for gliomas.[4]
- Patients who undergo awake craniotomy experience better early postoperative motor outcomes and shorter hospital stays than patients who undergo the same procedure asleep.[5]

Dr. Angela Bohnen, fellowship trained at Mayo Clinic in treating complex brain tumors, performs awake craniotomies at Neurosurgery One.

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More About Awake Craniotomy

Awake craniotomy is most frequently used in patients who have tumors located inside the brain, but some patients with tumors that are outside the brain that are pushing on critical areas of the brain may be candidates as well.

Patients with gliomas may benefit from awake craniotomy. Gliomas are the most common type of primary brain tumor in adults. Gliomas form in the glial cells, which are non-neural cells in the central nervous system that support homeostasis and function.

HOW AWAKE CRANIOTOMY IS PERFORMED

Patients are given a scalp block and put under sedation while the skull is opened and the tumor accessed. Then the anesthesia is removed and the patient wakes fully. Because the brain does not contain pain receptors, patients do not feel discomfort. The neurosurgeon then uses functional MRI (fMRI) and/or fiber tractography to map the brain while the patient performs tasks, like making movements, reading, naming objects, or performing spatial tasks. While the patient performs the tasks, the neurosurgeon plans the tumor resection to remove as much of the tumor as possible while protecting areas responsible for cognitive and functional skills. The patient is then sedated as the neurosurgeon completes the procedure and closes the skull.

BENEFITS OF AWAKE CRANIOTOMY

Awake brain surgery for brain tumor removal has several benefits over traditional craniotomy. Awake craniotomy allows for tumor removal in more eloquent areas of the brain, resulting in greater tumor resection without negatively affecting brain function. The procedure also requires less anesthesia, and it often results in a shorter hospital stay and lower costs when compared to asleep craniotomy. In some studies, patients of awake craniotomy spent 40% less time in the hospital than those undergoing traditional craniotomy. Like traditional craniotomies, your outcome will depend largely upon the size and location of your brain tumor(s). If your neurosurgeon was able to remove enough of the tumor(s) to relieve symptoms and it does not regrow, you may never need further treatment.

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Other Types of Brain Tumor Treatment Options

Surgery may not be the optimal treatment for all brain tumors or for all brain tumor patients. Depending on the type, size, and location of your tumor(s), as well as your personal preferences and goals, your neurosurgeon also may recommend or discuss alternative options such as the following:

Stereotactic radiosurgery (SRS): Despite its name, stereotactic radiosurgery — which also is called Gamma Knife — is not a surgery. Rather, this procedure utilizes high-powered beams of radiation to specifically target the tumor. Radiosurgery typically can be completed in an outpatient setting with one procedure, unlike other radiation therapies that often require several rounds of treatment. Stereotactic radiosurgery is often recommended for small cancerous and noncancerous tumors that are difficult to access through traditional surgery. This treatment may also be recommended for arteriovenous fistula (AVF), metastatic tumors, acoustic neuromas, and pituitary tumors. Complication rates are known to be lower with radiosurgery than open surgery. According to research, Gamma Knife radiosurgery has been found to be as effective as surgical approaches in smaller brain metastases.[6] Radiosurgery also has been shown to provide effective and predictable control of single and multiple brain metastases even in traditionally radioresistant metastases like those that are a result of renal cancer or melanoma.[7]

Optune: For patients 22 and older with newly diagnosed and recurrent glioblastoma (GBM), Neurosurgery One offers the FDA-approved portable and wearable Optune device. Optune, typically used along with chemotherapy, uses wavelike electric fields — called Tumor Treating Fields (TTFields) — to slow or stop glioblastoma tumor cells from dividing, and may destroy them.

Chemotherapy and immune therapy: Chemotherapy may be used to treat certain types of brain tumors, such as glioblastoma. It also may be used to control the originating cancer in cases of metastatic brain cancer.

Radiation: When possible, targeted stereotactic radiosurgery or surgery are often preferred over whole brain radiation for patients with single brain metastasis.[8]

Laser Interstitial Thermal Therapy (LITT): A relatively new procedure for brain tumor removal, LITT uses a laser to heat and destroy tumors. LITT may be an option for tumors that cannot be safely reached through craniotomy.

Selecting a Neurosurgeon

Choosing a neurosurgeon to treat your tumor is an important choice that will impact not only your physical health but also your mental and emotional health during your care and recovery. As you choose any healthcare provider, be sure to assess your comfort and confidence in the clinical team as well as how they communicate and support you and those caring for you.

Here are some questions that can help you assess a neurosurgeon:

- What is your training in neurosurgery? Are you fellowship-trained?
- Do you specialize in brain tumors and/or skull base tumors?
- How often have you completed this type of brain surgery? What are your success and infection rates?
- What evidence can you provide that supports moving forward with this type of surgery?
- Are there other options besides surgery for my condition?
- What are the pros and cons of this type of surgery?
- What can I expect before, during, and after surgery?
- Where do you perform surgery?
- What can I expect in terms of communication with you and your team? Can I contact you directly?

Also, consider these aspects of your interactions with the neurosurgery team:

- Do you feel like your goals and needs are understood and addressed?
- Does the team listen to and answer your questions?
- Does the neurosurgeon make you feel comfortable and confident?

About Neurosurgery One

We are honored that you are considering Neurosurgery One to provide your care. We have been serving patients in Denver and throughout the Rocky Mountain region for nearly 30 years. Our patient philosophy is to provide our patients with unbiased information that is supported by medical research on all treatment options, whether those options are delivered by our practice or we need to make a referral to another specialist. We provide information on the pros and cons of each of your options and help you explore the right treatment for your condition, your lifestyle, and your goals. We welcome inquisitive patients and those who have not found a complete answer to their condition or questions. We try hard to answer all of your questions, even if your questions question our advice, and we welcome second opinions if they will help you feel more confident in our recommendations.

WHY CHOOSE NEUROSURGERY ONE?

- Our practice provides fellowship-trained neurosurgeons, including a neurosurgeon specially trained in awake craniotomy.
- We offer the latest surgical advancements, including brain mapping and awake craniotomy.
- Our complication and infection rates are equal or better than national averages.

Our Commitment

We will listen closely to understand your story, goals, and questions.

We will provide information in a way that you can understand.

We will help you understand your options.

We will be beside you during your care journey.

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Expert Neurosurgeons

Neurosurgery One is pleased to offer one of the top teams for brain tumor surgery in the region.
Our neurosurgeons specializing in treatment of tumors include:

Wissam Asfahani, MD, FAANS, has 12 years of experience treating brain and spine disorders using surgical and nonsurgical therapies, including minimally invasive spine surgery.

Angela M. Bohnen, MD, FAANS, is fellowship trained in the management of complex brain tumors and performs specialized brain tumor surgery.

John Hudson, MD, PhD, is an expert in neuroendoscopic and other minimally invasive approaches to brain surgery. He also provides treatment for general spinal disorders.

Lloyd Mobley III, MD, FAANS, specializes in nonsurgical management and minimally invasive surgery for spine disorders, as well as complex surgical procedures for spine and brain conditions.

J. Adair Prall, MD, is a national expert on trigeminal neuralgia and also specializes in treating complex tumors, vascular malformations, and spinal disorders.

David VanSickle, MD, PhD, is one of the country's preeminent surgeons pioneering the use of Asleep DBS surgery. He also provides treatment for brain tumors and spine disorders.

Locations

Neurosurgery One has six locations across the Denver area.

Castle Rock 4350 Limelight Ave., Suite 100 • 80109

Lakewood 11750 W. Second Place, Suite 255 • 80228

Littleton 7780 S. Broadway, Suite 350 • 80122

Lone Tree/Park Meadows 9980 Park Meadows Drive, Suite 101 • 80124

Lone Tree/Yosemite 9695 S Yosemite, Suite 377 • 80124

Parker 9403 Crown Crest Blvd., Suite 200 • 80138

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Other Services Provided by Neurosurgery One

Neurosurgery One is Denver's most comprehensive neurosurgical practice. In addition to treating brain, skull base, and pituitary tumors, we also provide:

- Comprehensive spine care, including nonsurgical pain management, spine surgery, minimally invasive cervical disc arthroplasty, and complex spine deformity surgery
- Sacroiliac joint dysfunction diagnosis and treatment, including SI fusion
- Robotic-Assisted Asleep Deep Brain Stimulation (DBS)
- Three types of surgery for trigeminal neuralgia (TN)
- Neuromodulation for pain
- Surgery for brain and spine tumors
- Stereotactic radiosurgery
- Vagal nerve stimulation, responsive neurostimulation, DBS, and laser ablation for epilepsy
- Vascular surgery for aneurysms and arteriovenous malformations
- Peripheral nerve surgery
- Treatment for normal pressure hydrocephalus
- Emergency surgery for traumatic brain and spine injuries
- Carpal tunnel syndrome

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