Fully Endoscopic Resection of Pineal Region Tumors

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Abstract

Keywords

- pineal tumors
- parenchymal tumors
- infratentorial supracerebellar
- cerebellar tissue

Background and Objective Surgical treatment for pineal tumors is technically challenging—weighing the risks and benefits of microsurgical resection for the patient with a pineal tumor versus settling for an endoscopic third ventriculostomy and biopsy is sometimes difficult. Traditional microsurgical resection for pineal region tumors has typically required large open craniotomies and involvement or retraction of neural tissue with significant mortality and morbidity. With the advancement of high-resolution fiber optics, a fully endoscopic, supracerebellar, infratentorial approach, without any cerebellar retraction or manipulation of neural tissue, is introduced for the gross total resection of pineal region tumors.

Conclusion As an endoscopic modification of the open craniotomy procedure, this technique combines the advantages and benefits of both open microsurgical resection and minimally invasive endoscopic surgeries.

Introduction

Pineal tumors account for approximately 0.5 to 2% of all brain tumors, with germ cell and parenchymal tumors being the most common. Although pineal tumors were first recognized in 1717, initial attempts at surgery in this region were not performed until the 1900s. The pineal region is positioned at the geometric center of the brain—one of the most surgically inaccessible areas. Horsley initially attempted removing a pineal mass in 1910¹; Oppenheim and Krause reported the first successful removal of a tumor in 1913.² Beginning with Dandy (who performed the posterior transcallosal approach in 1921), Krause (who used the infratentorial supracerebellar approach in 1926), and Van Wagenan (who used the posterior transcortical transventricular approach in 1931), surgical treatment of pineal tumors has become more successful with less mortality and morbidity rates. Refinements and modifications of these surgical approaches, along with advances in microsurgery, have reduced the mortality of direct surgery to under 5% and morbidity to a minimum.^{3,4} In 1971,

Stein⁵ and—separately—Jamieson,⁶ performed a modified microsurgical infratentorial supracerebellar approach that is commonly used today^{7,8} along with a modified microsurgical occipital transtentorial approach^{7,9} that was first pioneered by Brunner.¹⁰ These approaches still require retraction of cerebellar tissue with associated complications.

In 2008, a fully endoscopic supracerebellar infratentorial approach for the resection of pineal region tumors was introduced. This procedure is vastly different from the traditional open craniotomy and microsurgical approaches being performed today. Rather than creating large openings in the skull and manipulating cerebellar tissue to access the tumor for resection, the fully endoscopic approach allows the procedure to be performed through a small keyhole opening and through the use of high-definition fiber optic technology, reaching the tumor without touching the brain. Using 2.7-mm endoscopes and high-resolution screens, the tumor and its complete topography from multiple angles is visualized without the complications associated with brain retraction. Use of custom endoscopic surgical instrumentation then

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allows for a safe and gradual resection of the tumor, piece by piece, through the dime-sized opening.

Advancements in technology have paralleled advances in endoscopic skull base surgery, as conventional neurosurgical and microsurgical instruments are too bulky for use. Whereas operating microscopes require wide viewing portals for adequate illumination and visualization of the operative field, endoscopes utilize minute keyholes to precisely reach the target area. Adapting and refining regular microinstruments and equipment, such as bipolars and Cavitron ultrasonic aspirators (CUSAs), to include longer more slender shafts and smaller microtips has been essential for endoscopic skull base surgery. With the supracerebellar approach to pineal tumors, customized endoscopic bipolars with insulated sheaths and small microtips are used for easy introduction, 360-degree rotation, and maneuverability through the keyhole opening. In addition, major improvements such as cold light sources, high-definition digital cameras and monitors, lens irrigation systems, and pneumatically powered robotic holding arms have all complemented the advances in endoscopic technology and stimulated the creation of dedicated endoscopic equipment specifically designed to fulfill the unique requirements of endoscopic skull base surgery for pineal region tumor excision.

Surgical Technique

The surgical procedure begins with the patient in a semi-sitting position (►Fig. 1). The patient's head is secured in a Mayfield three-pin head clamp. The head is then slightly flexed. A 2.5-cm incision is placed at theinion; this is followed by dissection of the soft tissues of the scalp down to the cranium using electrocautery and periosteal elevators. Hooks are used to retract the skin and soft tissues. A Stryker (Kalamazoo, Michigan, USA) saber drill is used to perform a 1.5-to-2-cm keyhole craniotomy centered at theinion just at the confluence of the transverse sinuses and superior sagittal sinus; diamond burrs are used to mitigate any inadvertent injury to the venous sinuses. A curvilinear incision is made in the dura, which is then retracted superiorly and held in place with Nurolon sutures (Ethicon, Somerville, New Jersey, USA).

Fig. 1 Photograph of patient positioning for the fully endoscopic infratentorial, supracerebellar approach.

The cerebrospinal fluid is allowed to slowly drain. The combination of mild hyperventilation, mannitol, and gravity cause the cerebellar tonsils to hang dependently and allows the opening of a path in the supracerebellar and infratentorial space. A 2.7-mm, 0-degree endoscope (Storz, Culver City, California, USA) is then guided atraumatically along this path with minimal dissection and occasional bipolar cauterization of a tentorial vein and no retraction of cerebellar tissues. An irrigation sheath attached to the endoscope clears blood and debris from the lens, avoids any heat generation from the endoscope, and eliminates the time-consuming and unsafe practice of removing and reinserting the endoscope. A rigid pneumatic holding arm secures the endoscope in position, allowing bimanual surgical dexterity. ►Fig. 2 illustrates the pathway of the endoscope in this approach.

Upon entering the supracerebellar infratentorial space, the surgeon conducts a preliminary survey and looks for any minor tentorial veins. These are electrocoagulated and sharply divided. Following this the endoscope is gradually advanced to the area of the pineal tumor, which is normally surrounded by a confluence of veins and arachnoid adhesions. Once the surrounding critical structures are identified, tumor dissection takes place guided by the 0-degree endoscope in much the same manner as the microsurgical procedure. Using microdissecting instruments that are custom designed for this endoscopic procedure, as well as the CUSA ultrasonic dissector, the interior of the pineal tumor is debulked first, followed by the microdissection and excision

Fig. 2 Illustration depicting pathway of endoscope for the fully endoscopic infratentorial, supracerebellar approach.

Fig. 3 Preoperative magnetic resonance imaging of 30-year-old female patient with a 2.7 cm pineoblastoma.

Fig. 4 Magnetic resonance imaging 3 months post-gross total resection via fully endoscopic approach.

of the capsule. Depending on the overall size and histology of the tumor, sharp dissection of the tumor off of the quadrigeminal plate inferiorly and chasing of the tumor into the third ventricle is often required. Great care is taken to avoid any injury to the surrounding critical neurovascular structures. Once gross tumor resection is complete, the 0-degree endoscope is removed and a 30-degree endoscope is inserted to perform a circumferential survey and examine the quadrigeminal plate, the inner walls of the third ventricle, and the opening of the aqueduct of Sylvius. Once the inspection is completed, the 30-degree endoscope is removed and a final survey of the tumor bed and surrounding structures is performed with the 0-degree endoscope to ensure hemostasis. The 0-degree endoscope is then removed and the dura is reapproximated with Nurolon sutures. The bone flap is replaced and secured with an absorbable microplate and microscrews, and the scalp is closed in anatomical layers without any drains.

Patients are extubated on the operating room table and taken to the recovery room. An average of 3 hours is spent in the recovery room, where their neurologic condition is examined with specific attention being focused at the possibility of double vision and other cranial nerve problems. Patients are

not taken to an intensive care unit but are transferred to a private room with one-to-one nursing care for about 24 hours. Most patients are discharged within 48 hours.

This technique is used for a variety of pineal region tumors, including pineocytomas, pineoblastomas, meningiomas, germinomas, astrocytomas, gliomas, teratomas, epidermoids, and complex pineal and arachnoid cysts.

Illustrative Case

►**Fig. 3** and ►**Fig. 4** show the preoperative and postoperative magnetic resonance imaging (MRI) images of a 30-year-old female patient with a 2.7-cm pineoblastoma that underwent a gross total resection via the fully endoscopic supracerebellar infratentorial approach.

Conclusion

Surgery for pineal region tumors has traditionally required large craniotomies, either going through neural tissue in the posterior transcortical and posterior transcallosal approaches or—at a minimum—requiring significant brain retraction in the infratentorial supracerebellar approach. Thus far, endoscopic approaches to the pineal region have been limited to transventricular approaches to perform an endoscopic third ventriculostomy (ETV), with a simultaneous biopsy of the pineal tumor while in the third ventricle. We describe a novel, fully endoscopic approach that is performed through a 1.5-to-2-cm occipital bur hole centered at the inion. This approach requires no violation of neural tissues, nor any cerebellar retraction, and allows the gross total resection of pineal region tumors such as pineocytomas, pineoblastomas, meningiomas, etc. This innovative technique combines the benefits of the traditional, open, supracerebellar infratentorial technique and avoids any of the complications secondary to retraction of the cerebellum. The fully endoscopic supracerebellar infratentorial approach also benefits from all the advantages of minimally invasive endoscopic techniques, such as shorter surgical time (2 hours), shorter hospitalization (48 hours), and fewer complications overall. We have been using this technique exclusively since 2008 and are currently in the process of compiling data for a follow-up article on a series of pineal region tumors using the above-mentioned technique.

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