

Infratentorial Supracerebellar Approach Versus Occipital Transtentorial Approach for Pineal Region Tumors: our technical considerations

Abordagem Supracerebelar Infratentorial Versus Occipital Transtentorial para Tumores da Região Pineal: nossas considerações técnicas

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ABSTRACT

Introduction: Despite the deep-seated location of pineal region tumors, surgical resection has become safer and more effective, and now plays an essential role in their management. Tissue diagnosis allows the initiation of chemotherapy or radiotherapy, and resection can be curative or improve the efficacy of adjuvant therapies. **Objective:** Infratentorial supracerebellar (ITSC) and occipital transtentorial (OTT) approaches are the most used for pineal tumors resection. This study aims to describe feasible criteria for better approach indication based on our surgical experience. **Methods:** Forty-two patients were divided for tumor resection, using tentorial surface angle in sagittal MRI view in the approach selection: Group 1 (25 ITSC); Group 2 (15 OTT); Group 3 (two combined approaches). **Results:** Group 1 achieved successful total removal. It was observed one visual impairment, one hydrocephalus patient with postoperative meningitis, and other one with postoperative hematoma. Group 2 presented 13 total resections, one visual impairment and transient contralateral hemianesthesia. Group 3 resulted in one air embolism and one ventriculitis after ventriculoperitoneal shunt. No surgical mortality registered. **Conclusion:** A descriptive analysis of 42 pineal tumor cases showed minimal complications. The ideal approach is well decided based on the angle between tentorial surface and vertical midline on sagittal plane.

Keywords: Pineal region tumors; Occipital transtentorial approach; Supracerebellar infratentorial approach

RESUMO

Introdução: Apesar da localização profunda dos tumores da região pineal, a ressecção cirúrgica tornou-se mais segura e eficaz e desempenha agora um papel essencial na sua gestão. O diagnóstico tecidual permite o início da quimioterapia ou radioterapia e a ressecção pode ser curativa ou melhorar a eficácia das terapias adjuvantes. **Objetivo:** As abordagens supracerebelar infratentorial (ITSC) e a transtentorial occipital (OTT) são as mais utilizadas para a ressecção de tumores pineais. Este estudo visa descrever critérios viáveis para uma melhor indicação de abordagem com base na nossa experiência cirúrgica. **Métodos:** Quarenta e dois pacientes foram divididos para ressecção tumoral, utilizando o ângulo da superfície tentorial em corte sagital por ressonância magnética na seleção da abordagem: Grupo 1 (25 ITSC); Grupo 2 (15 OTT); e Grupo 3 (duas abordagens combinadas). **Resultados:** O Grupo 1 obteve sucesso na remoção total. Foi observada uma deficiência visual, uma hidrocefalia em paciente com meningite pós-operatória, e outro com hematoma pós-operatório. O Grupo 2 apresentou 13 ressecções totais, uma deficiência visual e hemianestesia contralateral transitória. O Grupo 3 resultou em uma embolia aérea e uma ventriculite após derivação ventriculoperitoneal. Nenhuma mortalidade cirúrgica foi registrada. **Conclusão:** Uma análise descritiva de 42 casos de tumores da pineal mostrou o mínimo de complicações. A abordagem ideal é bem decidida com base no ângulo entre a superfície tentorial e a linha média vertical no plano sagital.

Palavras-chave: Tumores da região pineal; Abordagem occipital transtentorial; Abordagem supracerebelar infratentorial

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INTRODUCTION

Despite the deep-seated location of pineal region tumors, the surgical resection has become safer and more effective, and now plays an essential role in their management. Tissue diagnosis allows the initiation of chemotherapy or radiotherapy, and resection can be curative or improve the efficacy of adjuvant therapies. Several approaches have been reported, since the first attempt in 1910 to resect tumors in the pineal region¹. Among those, the infratentorial supracerebellar (ITSC) and occipital transtentorial (OTT) approaches are most used and provide excellent exposure while allowing minimally invasive and relatively low-risk access to the majority of pineal region tumors with the current techniques.

In some cases, the ITSC approach is a challenging route due to the angle of the surgeon view over cerebellar and tentorial surfaces in a horizontal plane. These characteristics are found mostly in a small posterior fossa with a vertical tentorium and, despite the help of gravity to drop the cerebellum downward in the semi-sitting position, this approach is not recommended^{2,3}. The more acute this angle, the more difficult is the direct view, with also more discomfort for the surgeon.

The anatomical variations of the straight sinus have already been described⁴. However, there are only few studies that describe the validity of this angle to choose the best approach and there is no consensus of an appropriate measure of tentorial angulation⁵⁻⁸. We describe here a simple, feasible and reproducible tool that can also be very helpful to choose the best approach for pineal region tumors.

METHODS

This retrospective single-institution study was conducted under the approval of the ethics committee of our institutional review board.

The records of all patients who had undergone surgical resection of pineal region tumors at the first author's institution over a 23-year period (July 1, 1994–February 18, 2017), were examined. The search revealed 42 patients and they were divided into three groups: Group 1, submitted to ITSC approach; Group 2, submitted to an OTT approach; and Group 3 (two patients), submitted to a combined approach.

The decision among approaches took into account the angle between the straight sinus and a vertical line in midline sagittal MRI (magnetic resonance imaging) view by the senior author, pre-operatively.

The ITSC route was chosen when the angle was greater than 45° and the OTT route when less than 45° (Figure 1). The combined approach was chosen when the tumor had a supra- and infratentorial extension according to the classification of Aguiar et al. for tentorial meningiomas⁹. The specifications of those three approaches are described in Figures 2, 3 and 4.

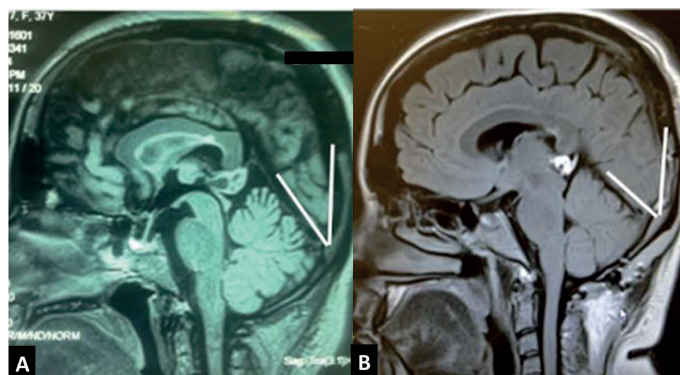


Figure 1. Proposed method for choosing the route to access the pineal region, taking into account the angle between a line perpendicular to the sagittal plane, beginning in the torcula, and a line parallel to the tentorium. The OTT route was chosen when this angle was less than 45° (A), and the ITSC route when the angle was greater than 45° (B).

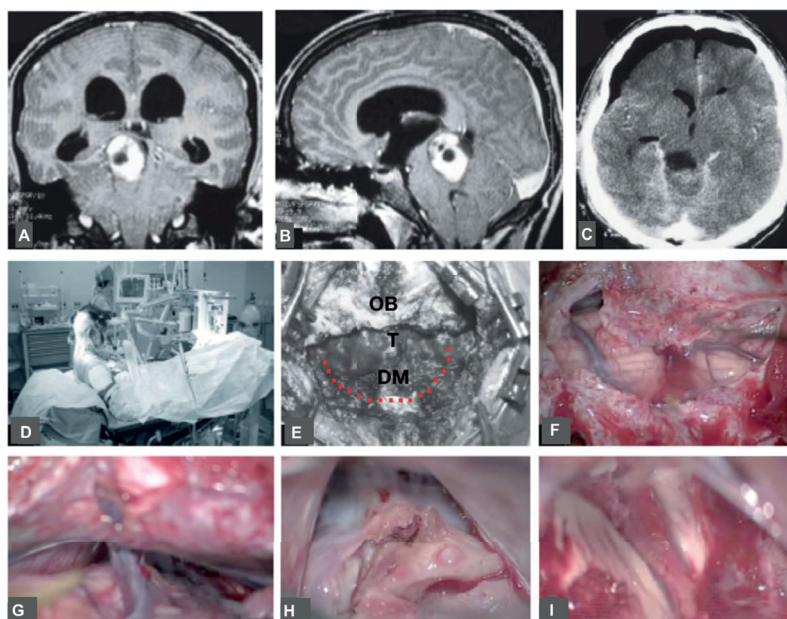


Figure 2. Gadolinium enhanced T1-weighted MR images of a pineal region tumor. **A.** Coronal. **B.** Sagittal. An angle greater than 45° and most of the tumor located below the lamina quadrigemina indicated the ITSC route. The postoperative computed tomography (CT) scan confirmed total tumor removal and resolution of hydrocephalus (**C**). The patients were placed in a semi-sitting position (**D**), and a transesophageal Doppler was used to detect air embolism. In the last 12 cases, the patients were submitted to neurophysiological monitoring. A suboccipital craniectomy was performed, with exposure of the transversus sinus, and usually without opening of C1 arch. **E.** The location of dura-mater opening is showed by the red dotted line. **F.** The dura-mater was opened in and elevated, with central vermian vein coagulation after its identification (**G**). Surgical view of a heterogeneous and multilobulated lesion, later confirmed as an undifferentiated teratoma (**H**) and after its total removal (**I**). OB: Occipital bone; T: torcula; DM: dura-mater.

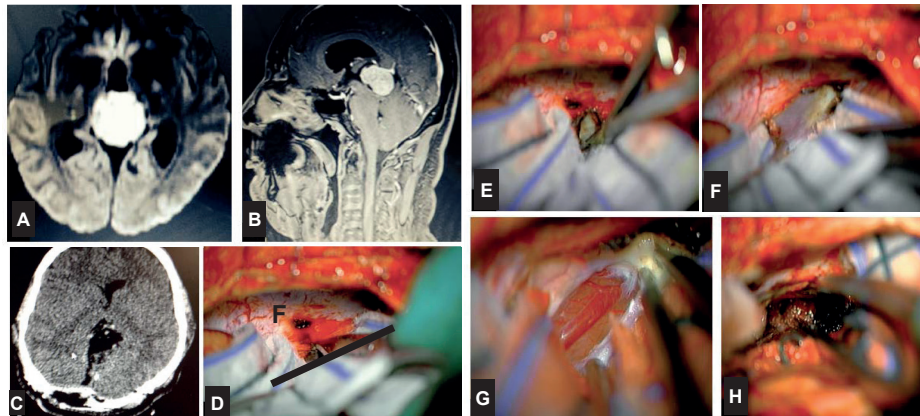


Figure 3. MRI images show a large tumor in pineal region. **A.** Axial DWI-weighted. **B.** sagittal Gadolinium enhanced T1-weighted. The OTT approach was performed, taking into account the favorable angle for this route. **C.** Postoperative CT scan shows an adequate resection. For this approach, the patients were placed in three-quarter prone position, on the right lateral side. A parieto-occipital craniotomy was performed, below the superior sagittal sinus and exposing the transverse sinus. The dura mater was opened in a C-shaped fashion with the convexity turned away from the superior sagittal sinus. **D.** The black line shows de straight sinus orientation. **E.** The falx was incised and **F.** coagulated. The incision was extended parallel to the straight sinus to visualize the surgical corridor. **G.** After opening the falx and tentorium, the tumor was visualized, with a large tumor vessel above it. **H.** Total microsurgical removal.

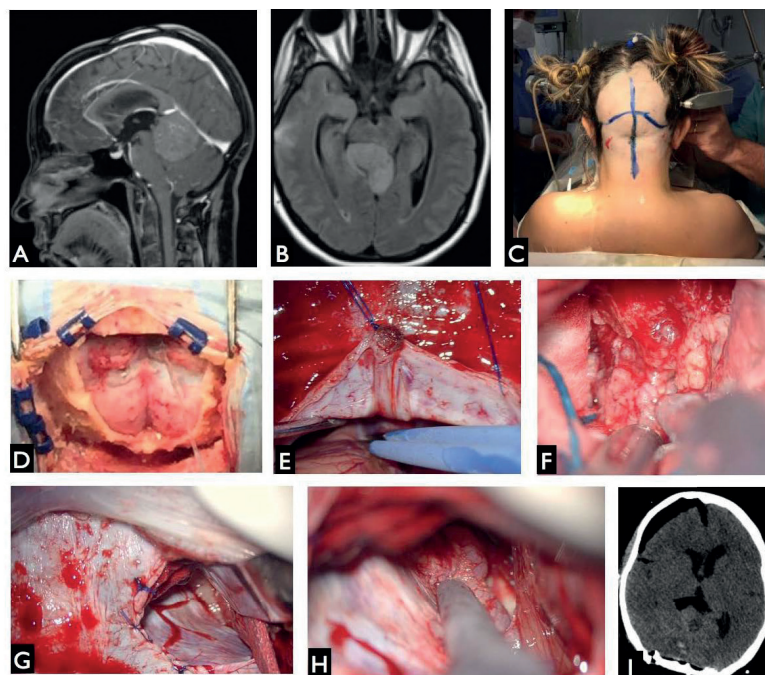


Figure 4. A combined approach case. **A.** Sagittal Gadolinium enhanced T1-weighted and **B.** axial FLAIR-weighted. **C.** MRI images of a torcular meningioma, located mainly in the pineal region. The patient was placed in a semi-sitting position. **D.** A biparieto-occipital craniotomy was performed above the transverse sinus, combined with a suboccipital craniotomy, to expose the torcula and transverse sinus and superior sagittal sinus. **E.** The dura mater was opened in a C-shaped fashion, and the infratentorial portion of the tumor was exposed and resected. **G.** The tentorium and/or falx were opened if necessary (not essential in this case) and **H.** the remaining lesion finally resected. **I.** Postoperative CT scan revealed total removal. T = torcula; TS = transverse sinus; SSS = superior sagittal sinus.

RESULTS

The Group 1 (25 patients) had a mean age of 42.4 years (2-73 years) and included 13 women (52%). A successful total resection was achieved in all patients, despite their different diagnosis (ten pineocytomas, two pineoblastomas, two epidermoid tumors, one cavernoma, eight meningiomas, one lymphoma and one glioma). After surgery the visual impairment was observed in one patient, hydrocephalus in one patient with postoperative meningitis, and one surgical bed hematoma that was surgically treated. Air embolism was detected in two patients (one with lymphoma and another with meningioma), but without clinical relevance.

In Group 2 (15 patients) the mean age was 26.5 years (21-39 years) and included 9 (60%) women. Thirteen patients had their tumor totally resected. Partial resection in the other two patients was due to technical difficulties in finding a cleavage

plane between the tumor and the internal cerebral and basal veins. The histopathological diagnosis in these two patients was meningioma. The histological diagnosis of the other cases was: five pineocytomas, two pineoblastomas, one teratoma, one endodermal yolk sac tumor and six meningiomas. One case resulted in visual impairment and transient contralateral hemianesthesia.

Group 3 consisted of two women, with mean age of 37 years and both patients had a histological diagnosis of meningioma. Air embolism was detected in one case and ventriculitis after ventriculoperitoneal shunt in another. In one case, a traumatic pneumothorax was observed in the intraoperative period, and the patient underwent thoracic drainage. There was no surgical mortality in any of the three groups. Data are summarized in Table 1.

Table 1. Patients included in the study.

Group	Approach	N	Mean age (range)	Diagnosis (N)	Patient positioning	Resection	Complications
1	Infratentorial supracerebellar	25	42.4 y (2-73 y)	Pineocytoma (10) Meningioma (8) Pineoblastoma (2) Epidermoid tumor (2) Cavernoma (1) Lymphoma (1) Glioma (1)	Semi-sitting	Total	Visual impairment Hydrocephalus Postoperative meningitis Post operative hematoma Air embolism
2	Suboccipital Transtentorial	15	26.5 y (21-39 y)	Meningioma (6) Pineocytoma (5) Pineoblastoma (2) Teratoma (1) Endodermal yolk sac tumor (1)	Three-quarter prone	Partial (2) Total (13)	Visual impairment Transient contralateral hemianesthesia
3	Combined	2	37 y	Meningioma (2)	Semi-sitting	Total	Air embolism Ventriculitis Pneumothorax

N: number of patients, y: years.

DISCUSSION

Surgery of pineal region pathology is considered difficult due to the limited access in a small and deep corridor. Several approaches have been proposed to achieve a safe resection, each one of them with its established benefits and limitations, and have been evolving over time with the addition of new technologies¹⁰. Microsurgical excision is still the mainstay of management for most pineal region tumors. An exception is germ cell tumors, in which treatment policies include radiotherapy and chemotherapy after obtaining a confirmed diagnosis, without the necessity of complete resection^{11,12}. The most commonly used approaches are the ITSC¹³ and OTT^{14,15}. In some cases, a combination of the two routes can be used, especially for large tumors. There are some less common approaches, that uses an anterior supratentorial corridor, such as interforaminal¹⁶ and anterior interhemispheric transsplenic approach¹⁷.

There are few studies concerning to the anatomic landmarks that could be helpful in achieving a better exposure or to determine the more adequate approach. The importance of straight sinus angulation was investigated by Hasegawa et al.⁴. The angle of the straight sinus to the nasion-tuberculum sellae line, the tuberculum sellae-inion line, and the nasion-inion line was measured and was designated as common type (63% of the MRI images), high-angle type (26%), or low-angle type (11%). The operative field was restricted by the steep tentorium in the case of the high-angle type, and the tumor was located much lower than the direction of the operative approach. This author suggested that the preoperative MRI analysis of the angle of the straight sinus is indispensable before choosing the infratentorial supracerebellar approach to the pineal region tumors. Also, Nayar et al.¹ described landmarks to guide head positioning to obtain the best work trajectory. The inion and coronal suture were considered landmarks to infer the straight sinus position, facilitating the head positioning before surgery, because registration and navigation take place after the head is fixed in its final position.

The tentorial angle definition has some diversion in the literature. For example, many authors have noted that a “steep tentorium” makes certain approaches more challenging, however there is no agreement in how to measure the tentorial angle among studies^{4-6,8}. In our vision, we assumed that the tentorial angle is measured between an imaginary line parallel to the straight sinus and another one perpendicular to an imaginary sagittal line located in the torcula, as showed in Figure 1. When an angle lesser than 45 degrees was observed in an infratentorial supracerebellar approach, some technical difficulties were observed. The route to reach the pineal region is very steep, even if an effective neck flexion was achieved. The exposure and resection of pineal region tumors and bleeding control of surrounding vessels turn to be more difficult.

The first author who described the “tentorial angle”, Samuel Wolpert, measured the angle between the straight sinus and a nasion-to-tuberculum sella line, in 1969¹⁹. Later, some authors^{4,5} described different methods to measure this anatomical landmark. For example, the “Twining line” (drawn from the tuberculum sella to the torcula)²⁰ was used as a reference line to estimate the tentorial angle. Lafazanov et al.⁵ reviewed cranial MRIs of 100 individuals to measure the steepness of the tentorium in relation to the twining line to perform paramedian supracerebellar-transtentorial approaches to expose the anterior portion of the mediobasal-temporal region. They concluded that the lesser the tentorial and occipital angles, the easier the exposure of the anterior portion of the mediobasal-temporal in this specific approach. Pan et al.⁷ compared the angle between the tentorium and a glabella-external occipital protuberance line to facilitate preoperative positioning. Nemir et al.⁶ conducted a retrospective study of midsagittal T1-weighted MRI images of 410 randomly selected healthy subjects. They measured the clivus-tentorium (C-T) angle to assess tentorial alignment. Also, it was studied craniocaudal cisternal measurements such as quadrigeminal cistern equal the superior colliculi-inferior part of the splenium of corpus callosum (SC-ISCC) and superior cerebellar cistern equal the vermis-inferior part of the splenium of corpus callosum (VER-ISCC). The C-T angle was negatively correlated with the SC-ISCC distance (r

= -0.271; $p < 0.001$) and the VER-ISCC distance ($r = -0.052$, $p > 0.001$). The SC-ISCC distance was positively correlated with the VER-ISCC distance ($r = 0.282$; $p < 0.001$).

However, Syed et al.⁸ states that the disagreement to define the “tentorial angle” resides in what “reference line” to use against the tentorium, in order to make the measurement. The majority of proposed angles use non posterior fossa structures as a reference (e.g., twining line)²¹ and can significantly underestimate the angle of the tentorium in patients with inferiorly-positioned, or low-lying torcula, which is associated with a steeper tentorium. As the tentorium is the roof of the posterior fossa, its angle should be measured against other structures of the posterior fossa as well.

It has already been discussed in the literature the challenge of a ITSC approach when the tentorial angle is very steep and the possibility to switch to transtentorial approach should be considered^{4,10,22-24}. Mbaye et al.³ suggested to switch to the OTT approach if the patient has small posterior fossa with vertical tentorium. There are retrospective case series that do not describe the tentorial angle as a criteria to decide between OTT or ITSC route^{18,25-27}. Some features included to decide the approach were, tumor size, its relation with venous complex, lateral extension^{15,18}, and arachnoid membranes²⁸. In Matsuo et al.²⁹ anatomical study of pineal region was described an off-midline route, useful in case of the need of a better view of the cerebellomesencephalic fissure, collicular plate, and trochlear nerve. Also, it can reduce the venous sacrifice.

The main goal of surgical approaches to achieve a complete resection is challenged by a complex anatomy and vascular relationships. Bruce and Stein¹⁰ reported a large series of surgery of pineal region tumors in 160 patients mainly using the ITSC approach (86% of cases). A gross total tumor removal was possible in 31 of 107 malignant tumors. Konovalov and Pitskhelauri² reported a series of 244 patients using OTT approach in 138 procedures (54%), and ITSC in 87 cases (34%). Total tumor removal was achieved in 148 operations (58%) and subtotal in 74 (29%), while partial tumor removal was achieved in 33 (13%) surgeries. The OTT approach was preferred in both studies for large tumors and lateral

expansion and there is no mention of the use of tentorial angle as criteria to choose the approach. In a retrospective review of 143 patients by Qi et al.²⁸, with nongerminomatous pineal region tumors operated via an OTT approach, gross total tumor removal was achieved in 91.6% of patients, subtotal in 7%, and partial in 1.4%. In our series, total resection was achieved in the majority of patients, with only two cases with partial resection due to more invasive tumors, despite the heterogeneous histological diagnosis.

CONCLUSIONS

This is a retrospective series of tentorial angle approaches for pineal region tumors. Despite this study being descriptive and retrospective, some inferences can be made. The population is heterogeneous, however given the rarity of these lesions, some aspects regarding to the approach can be generalized. We considered this technique only valid for tumors that can be best reached by the midline. The paramedian supracerebellar routes, although considered fewer steep routes, are best indicated for more lateral tumors. Comparing to the literature, good results were obtained with this method choosing the best approach to resect pineal region tumors. A low rate of complications was found, and it was a safe and applicable method to guide surgeons to choose a route to operate on pathologies in the pineal region. Certainly, it is yet very important to take into account other factors, such as the relation of the tumor to the other surrounding structures, presence of hydrocephalus, tumor-feeding arteries and relationship with venous complex, neck flexibility, and tentorium length.

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