www.surgicalneurologyint.com

ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

Surgical Neurology International

Editor-in-Chief: Nancy E. Epstein, MD, Clinical Professor of Neurological Surgery, School of Medicine, State U. of NY at Stony Brook.

SNI: Skull Base

Editor
Mitsutoshi Nakada, MD
Kanazawa University, Ishikawa, Japan

SNI
Open Access

Technical Notes

Subtemporal approach for cavernous sinus meningiomas – Simple and effective

Michael Veldeman[1,2], Tobias Rossmann[2,3], Nuutti Vartiainen[2], Mika Niemela[4]

[1]Department of Neurosurgery, RWTH Aachen University Hospital, Aachen, Germany, [2]Department of Neurosurgery, University of Helsinki and Helsinki University Hospital, [3]Department of Neurosurgery, Neuromed Campus, Kepler University Hospital, Linz, Austria, [4]Department of Neurosurgery, University Hospital Helsinki, Helsinki, Finland.

E-mail: *Michael Veldeman - mveldeman@ukaachen.de; Tobias Rossmann - mveldeman@ukaachen.de; Nuutti Vartiainen - mveldeman@ukaachen.de; Mika Niemela - mveldeman@ukaachen.de

***Corresponding author:**
Michael Veldeman,
Department of Neurosurgery,
RWTH Aachen University
Hospital, Aachen, Germany.

mveldeman@ukaachen.de

Received : 03 November 2022
Accepted : 04 January 2023
Published : 20 January 2023

DOI
10.25259/SNI_1012_2022

Quick Response Code:

ABSTRACT

Background: Over the past few decades, there has been a paradigm shift in treatment strategy for cavernous sinus meningiomas (CSMs). Preserving neurological function and cranial nerve (CN) decompression have become the primary goal of cases eligible for surgical treatment. Extensive skull base dissection and drilling can be avoided by approaching these lesions through a subtemporal route.

Methods: We describe the subtemporal approach in a step-by-step fashion illustrating its advantages and pitfalls through and illustrative case.

Results: The subtemporal approach to CSMs is a valuable alternative for CN decompression and maximal safe resection. We describe the technique in comparison to classical skull base approaches. Although rare, recurrence after adjuvant maximal radiation is possible leaving reoperation as the only treatment option.

Conclusion: The subtemporal approach offers a less invasive alternative for initial and redo CN decompression and successful symptom control in patients suffering from CSM.

Keywords: Cavernous sinus, Meningioma, Skull base, Subtemporal approach

INTRODUCTION

Cavernous sinus meningioma (CSM) constitutes one of the most challenging skull base meningiomas to treat. Left untreated, CSM can cause ophthalmoplegia, visual loss, and endocrine disturbances. Due to the encasement of the carotid artery and cranial nerves (CNs) III, IV, V_1, V_2, and VI, the cavernous sinus was coined the "anatomical jewel box" by Dwight Parkinson.[1] The historical mainstay of CSM treatment has been gross total surgical resection[16] which can lead to considerable morbidity even in the most experienced hands.[13] Over the past few decades, there has been a paradigm shift in treatment strategy and goals, away from aggressive surgical management toward disease containment in a multidisciplinary fashion.[3,17] Stereotactic radiosurgery or stereotactic fractionated radiation has evolved into valuable alternatives or adjuncts to surgery.[15,17] Nevertheless, microsurgical resection remains a valid treatment option for progressive lesions in young symptomatic patients.[3] In large asymptomatic tumors, a wait-and-scan approach might be a viable option, as the onset of diplopia has proven not to be related to tumor size.[7]

The resectability of CSM depends mainly on the degree of internal carotid artery encasement similarly to Knosp's grading for pituitary adenoma.[10,14] The amount of tumor which can be safely resected is determined by its consistency, which can only be fully appreciated during surgery. Meningiomas' nature to encase or even grow into CNs oftentimes impedes total resection while preserving neurological function.[11] Nowadays, if biopsy or surgical resection is indicated, the extracavernous portion of the tumor is surgically targeted, aiming at CN decompression and symptom control. Surgery offers the additional advantage of providing histopathological confirmation. Adjuvant radiation can be performed in case of documented growth of the remaining intracavernous portion.[3,5,13,14]

CLASSICAL APPROACHES

A frontotemporal/pterional-type of approach with or without orbitozygomatic osteotomy is typically used for CSMs. Extensive extradural dissection by cutting and dividing the meningo-orbital band, drilling of the anterior clinoid and optic strut, and peeling off the temporal dura from the lateral cavernous sinus wall is usually performed.[6,18] After a Dolenc- or Hakuba-interdural dissection and durotomy, CNs are identified, and tumor is dissected between the appropriate anatomical triangles.[18] This anterolateral approach toward this region offers early identification and protection of the optic apparatus and access to both the anterior and posterior cavernous sinus. CNs can be identified and dissected as they converge toward the superior orbital fissure.

THE SUBTEMPORAL APPROACH

Approaching the cavernous sinus subtemporally eliminates the need for extensive drilling and provides a straight unobstructed route to the lateral wall of the cavernous sinus.

Positioning and craniotomy

The patient is placed in a park-bench position and to achieve adequate brain relaxation, a lumbar drain is placed, and 50 mL of cerebrospinal fluid (CSF) is removed before incision [Figure 1]. We previously described this approach for basilar bifurcation aneurysms.[8] In skull base tumor surgery, the subtemporal approach has been described for lesions in Meckel's cave[20] and parasellar chordomas[19] but to our knowledge not for CSM. A linear skin incision is made starting at the zygomatic arch, about 1 cm in front of the tragus and is carried straight upward to a length of around 6 cm [Figure 2]. After splitting the temporal muscle with monopolar cautery, a single-burr hole is placed at the lowest point of the planned craniotomy. A 3 cm craniotomy is made, and the dura is opened in a U-shaped fashion.

Temporal lobe elevations

Care is taken not to injure the vein of Labbé and the temporal lobe is carefully elevated using dynamic retraction with suction and bipolar only [Figure 1b]. The temporobasal cortical surface is protected with surgical patties and the medial temporal dura is identified. Rarely, smaller temporobasal bridging veins require to be sacrificed. Neuronavigation is used to help orientation along the middle fossa floor. The main objective is to acquire the correct trajectory until reaching the lateral borders of the cavernous sinus.

Tumor exposure and debulking

The dura overlaying the tumor is incised and the tumor is entered below the anticipated level of the oculomotor and trochlear nerve through the infratrochlear (Parkinson's) triangle [Figure 1c]. Tumor tissue is then either removed through suction or peeled with tumor grasping forceps. Total resection of the extracavernous portion is only feasible in case of soft ("suckable") tumor consistency. After entering the tumor capsule, the cavernous carotid artery is identified by means of Doppler sonography. Venous bleeding is controlled by gentle packing with oxidized cellulose and fibrin glue. After resection, the tumor cavity is covered with a fibrin sealant patch.

ILLUSTRATIVE CASE

A female patient in her late fifties sought medical advice due to fluctuating mild diplopia. Visual acuity was intact, and a partial CN VI palsy was diagnosed. Magnetic resonance imaging (MRI) revealed a homogenously contrast enhancing lesion of the right cavernous sinus consistent with CSM Hirsch grade II [Figure 3a].[9] Based on beginning external ophthalmoplegia and the patient's age, the decision to opt for surgical treatment was made. She was operated on in a park-bench position through the subtemporal route. Postoperative MRI after 3 months revealed no residual extracavernous tumor [Figure 3b], and at this point, the CN VI palsy had fully recovered. Histopathology confirmed the suspected diagnosis of a meningioma WHO grade I.

The patient was regularly followed with MRI. Two years later, mild growth of residual intracavernous tumor was documented on imaging, and subsequently, she underwent adjuvant radiotherapy. Fractionated stereotactic irradiation was administered up to 50.4 Gray in 2.8 Gray doses. She remained in regular follow-up, and symptoms of CN VI palsy with diplopia began to reoccur 10 years later. Considerable intra- and extracavernous tumor growth was, now documented

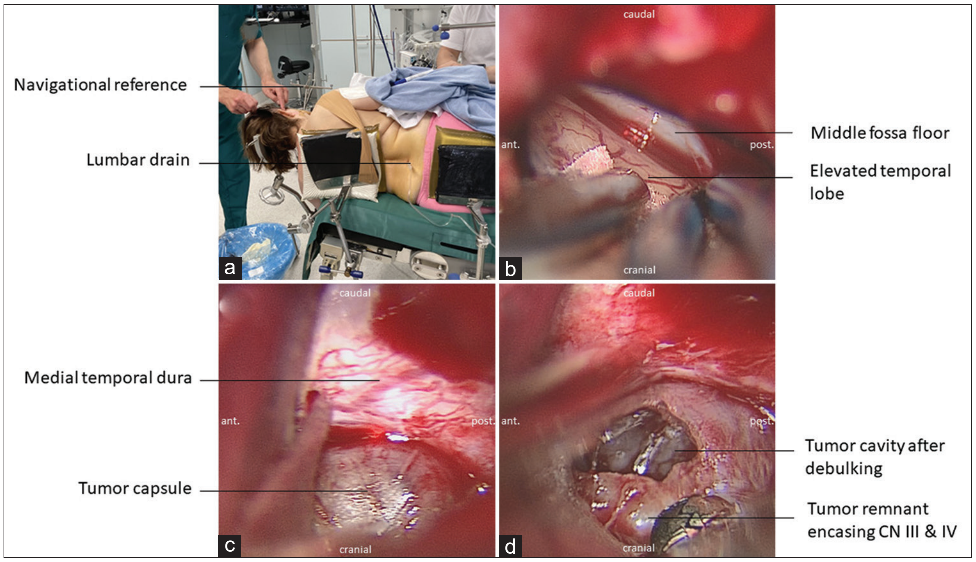

Figure 1: Surgical steps in cavernous sinus meningioma resection through the subtemporal approach. (a) The patient is placed in a park-bench position allowing 90-° head rotation without compromising venous outflow. A lumbar drain is placed, and 50 mL cerebrospinal fluid is drained before incision. (b) The temporal lobe is elevated exposing the floor of the middle fossa. (c) The tumor is identified after opening of the medial temporal dura. (d) Tumor tissue is either sucked or removed with grasping forceps. A "suckable" tumor consistency is of great benefit to achieve atraumatic tumor removal without cranial nerve injury.

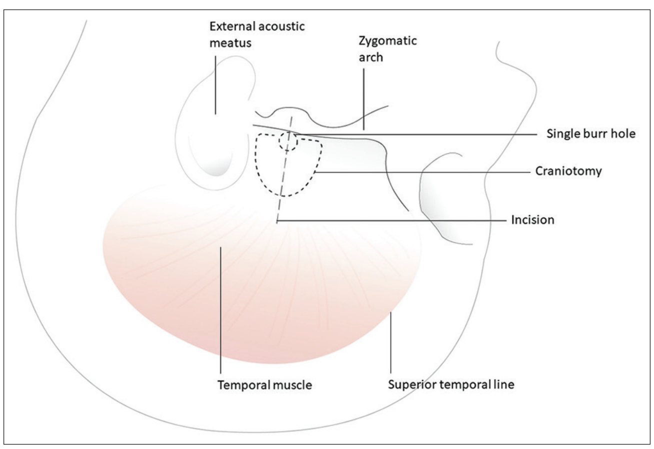

Figure 2: Schematic depiction of incision and craniotomy in relation to the relevant surface anatomy. A single-burr hole is made at the level of the middle fossa floor from which a semicircular craniotomy is performed.

on MRI demonstrating a now Hirsch grade III tumor with carotid encasement [Figure 4]. Original radiation treatment plans were reassessed, and due to a maximal permissible dose obtained by the optic apparatus, the patient was deemed unfit for repeated radiation. To prevent further worsening of ophthalmoplegia, the decision was made to reoperate through the same trajectory and achieve CN decompression. Postoperatively, patient's double vision fully recovered and early MRI documented internal tumor debulking/subtotal resection [Figures 4b-d]. She will be further followed clinically

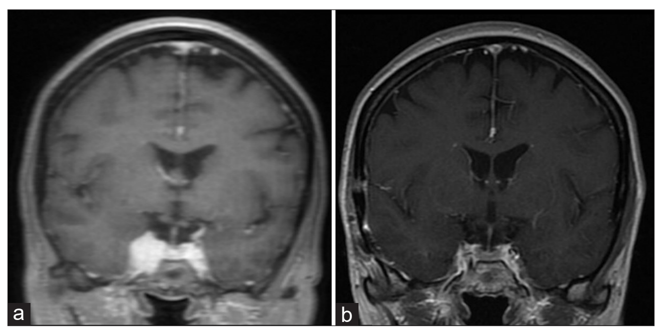

Figure 3: Pre- and postoperative coronal T1 contrast-enhanced magnetic resonance imaging. (a) Initial magnetic resonance (MR)-imaging revealed a homogenously contrast enhancing lesion of the right cavernous sinus consistent with cavernous sinus meningioma. (b) Three months after surgery, MR-imaging revealed no extracavernous residual tumor.

and radiologically. Surgical steps of the subtemporal approach to the cavernous sinus are depicted in Figure 1. The patient consented to the publication of images.

DISCUSSION

During the advent of microsurgical skull base development in the 1990s, the frontiers of what is possible at the level of the cavernous sinus were pushed.[16,18] An extensive skull base approach with anterior clinoidectomy and interdural dissection of the cavernous sinus' lateral wall has been the standard for resection of CSM. Despite offering an excellent

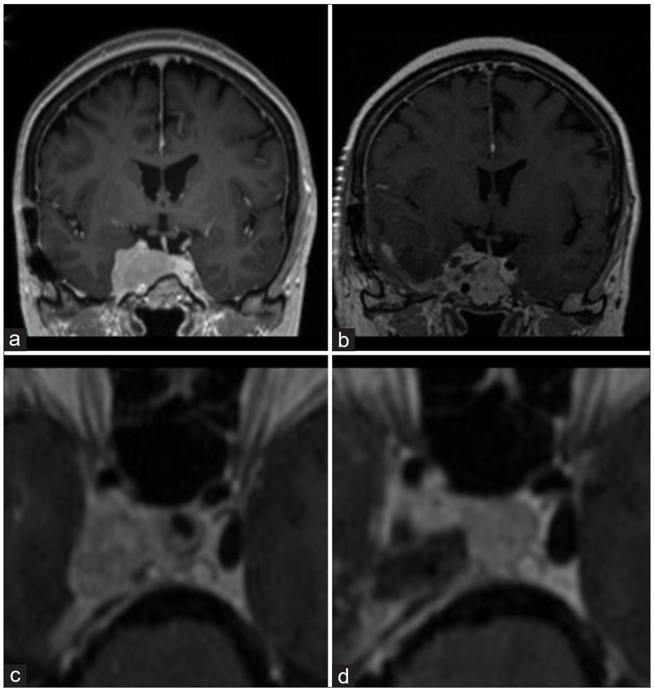

Figure 4: Pre- and postoperative coronal T1 contrast-enhanced magnetic resonance imaging. (a) Tumor recurrence despite adjuvant radiation after initial resection resulting in CN VI palsy. (b) Early postoperative magnetic resonance-imaging demonstrates internal tumor debulking to treat the cranial nerve compartment syndrome and achieve successful symptom control. (c) Preoperative axial close up T1 contrast-enhanced image of the cavernous sinus region. (d) Postoperative result after subtemporal tumor debulking.

anatomical exposure and the best potential of identifying CN V_1, V_2, III, and IV, complete resection functional preservation of CNs is oftentimes not feasible.[4] Aggressive removal of the CSMs has now made way for a more balanced approach between optimal resection, restoration of CN function, and maintaining quality of life.[3]

Alternatives to a frontotemporal approach have been suggested such as a transpetrosal approach[12] which, however, requires petrous bone drilling exposing the patient to associated risks, that is, hearing loss or carotid injury. Endonasal debulking has proven a valuable less invasive alternative to address CSM-induced CN palsies.[2] We present the subtemporal approach as a feasible alternative for initial resection but also to address recurrent tumor after radiation treatment. Scaring severely complicates surgical orientation and identification of CNs in redo or post-radiation surgery through an interdural approach. We believe targeting these lesions subtemporally provides an alternative to bypass bothersome interdural dissection in redo cases. As a disadvantage, this type of craniotomy provides less instrument maneuverability compared to a frontotemporal approach. The surgical corridor is limited by the space which can be gained by elevation of the temporal lobe. Sufficient CSF release is

Table 1: Overview of advantages and disadvantages of the subtemporal approach in the resection of cavernous sinus meningiomas in comparison to classical frontotemporal microsurgical approaches.

Advantages	Disadvantages
Short linear incision	Less maneuvering space
No need for ACP drilling	Not suitable for tumors affecting the CN II
Easy access to the posterior cavernous sinus	More difficult to access the anterior cavernous sinus
No need for bony repair upon closure	Potential conflict with temporobasal veins
Shorter operating time	Difficult to reach suprasellar tumor extensions
Less temporal muscle trauma a risk of atrophy	Necessity to open the dura (twice) and expose/manipulate cortex
Feasible for post-radiation and redo surgery	No devascularization before resection

ACP: Anterior clinoid process, CN II: Optic nerve

paramount to avoid contusions especially while accessing more cranial portions of the cavernous sinus. The orientation and trajectory along the middle fossa floor can be treacherous and the use of neuronavigation is advised. The dura requires to be opened twice and cortical brain surface is manipulated exposing the patient to risks of intradural bleeding or epileptic seizures. Through this approach, the optic nerve cannot be reached, nor visualized or decompressed, making it unsuitable for patients with affected vision. Before deciding on which surgical approach to use, temporobasal venous anatomy needs to be carefully studied on T2 MRI images as to identify relevant basal veins which would preclude the save elevation of the temporal lobe. The advantages and pitfalls of this approach are summarized in Table 1. Based on the above-mentioned disadvantages, this approach is not applicable for al CSMs. However, we believe that if surgery is indicated, a subtemporal decompression could be the preferred strategy in selected patients with CN deficits (without optic nerve involvement) despite small tumor size.

CONCLUSION

Recurrence of CSMs despite maximal safe resection and adjuvant radiation offers a formidable challenge. The subtemporal approach offers a straightforward, safe, and effective route for the resection of CSM and CN decompression, even in recurrent cases. Sufficient drainage of CSF is key to achieve atraumatic temporal lobe elevation. In the nowadays broadly accepted policy focusing on functional preservation and tumor containment over cure, the subtemporal route provides a less invasive and esthetically superior alternative to classical anterolateral skull base approaches.

DISCLOSURES

Role of the funding source

No funding bodies had any involvement in the preparation of this study or in the decision to submit the paper for publication.

Ethical statement

Ethical approval is not applicable to this technical report. The patient in the illustrative case provided written informed consent.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Ajisebutu A, Del Bigio MR, Kazina CJ, West M, Serletis D. Dr. Dwight Parkinson: A Canadian neurosurgical pioneer. J Neurosurg 2019;27:1-8.
2. Beer-Furlan A, Priddy BH, Jamshidi AO, Shaikhouni A, Prevedello LM, Filho LD, *et al*. Improving function in cavernous sinus meningiomas: A modern treatment algorithm. Front Neurol 2020;11:652.
3. Corniola MV, Roche PH, Bruneau M, Cavallo LM, Daniel RT, Messerer M, *et al*. Management of cavernous sinus meningiomas: Consensus statement on behalf of the EANS skull base section. Brain Spine 2022;2:100864.
4. DeMonte F, Smith HK, Al-Mefty O. Outcome of aggressive removal of cavernous sinus meningiomas. J Neurosurg 1994;81:245-51.
5. Gozal YM, Alzhrani G, Abou-Al-Shaar H, Azab MA, Walsh MT, Couldwell WT. Outcomes of decompressive surgery for cavernous sinus meningiomas: Long-term follow-up in 50 patients. J Neurosurg 2020;132:380-7.
6. Hakuba A, Tanaka K, Suzuki T, Nishimura S. A combined orbitozygomatic infratemporal epidural and subdural approach for lesions involving the entire cavernous sinus. J Neurosurg 1989;71:699-704.
7. Hekmatpanah J. Evidence-based treatment of cavernous sinus meningioma. Surg Neurol Int 2019;10:228.
8. Hernesniemi J, Ishii K, Niemelä M, Kivipelto L, Fujiki M, Shen H. Subtemporal approach to basilar bifurcation aneurysms: Advanced technique and clinical experience. Acta Neurochir Suppl 2005;94:31-8.
9. Hirsch WL, Sekhar LN, Lanzino G, Pomonis S, Sen CN. Meningiomas involving the cavernous sinus: Value of imaging for predicting surgical complications. AJR Am J Roentgenol 1993;160:1083-8.
10. Knosp E, Steiner E, Kitz K, Matula C. Pituitary adenomas with invasion of the cavernous sinus space: A magnetic resonance imaging classification compared with surgical findings. Neurosurgery 1993;33:610-7; discussion 617-8.
11. Larson JJ, van Loveren HR, Balko MG, Tew JM Jr. Evidence of meningioma infiltration into cranial nerves: Clinical implications for cavernous sinus meningiomas. J Neurosurg 1995;83:596-9.
12. Morisako H, Goto T, Ohata H, Goudihalli SR, Shirosaka K, Ohata K. Safe maximal resection of primary cavernous sinus meningiomas via a minimal anterior and posterior combined transpetrosal approach. Neurosurg Focus 2018;44:E11.
13. Nanda A, Thakur JD, Sonig A, Missios S. Microsurgical resectability, outcomes, and tumor control in meningiomas occupying the cavernous sinus. J Neurosurg 2016;125:378-92.
14. O'Sullivan MG, van Loveren HR, Tew JM Jr. The surgical resectability of meningiomas of the cavernous sinus. Neurosurgery 1997;40:238-44; discussion 245-37.
15. Roche PH, Régis J, Dufour H, Fournier HD, Delsanti C, Pellet W, *et al*. Gamma knife radiosurgery in the management of cavernous sinus meningiomas. J Neurosurg 2000;93 Suppl 3:68-73.
16. Shaffrey ME, Dolenc VV, Lanzino G, Wolcott WP, Shaffrey CI. Invasion of the internal carotid artery by cavernous sinus meningiomas. Surg Neurol 1999;52:167-71.
17. Umekawa M, Shinya Y, Hasegawa H, Shin M, Kawashima M, Katano A, *et al*. Long-term outcomes of stereotactic radiosurgery for skull base tumors involving the cavernous sinus. J Neurooncol 2022;156:377-86.
18. van Loveren HR, Keller JT, el-Kalliny M, Scodary DJ, Tew JM Jr. The dolenc technique for cavernous sinus exploration (cadaveric prosection). Technical note. J Neurosurg 1991;74:837-44.
19. Wang B, Li Q, Sun Y, Tong X. Surgical strategy for skull base chordomas: Transnasal midline approach or transcranial lateral approach. J Korean Neurosurg Soc 2022;65:457-68.
20. Youssef S, Kim EY, Aziz KM, Hemida S, Keller JT, van Loveren HR. The subtemporal interdural approach to dumbbell-shaped trigeminal schwannomas: Cadaveric prosection. Neurosurgery 2006;59:ONS270-7; discussion ONS277-8.

How to cite this article: Veldeman M, Rossmann T, Vartiainen N, Niemela M. Subtemporal approach for cavernous sinus meningiomas – simple and effective. Surg Neurol Int 2023;14:16.