Surgical Outcomes of Cerebellopontine Angle Meningiomas in Vietnam: A Single-Center Prospective Study

Duy Pham[1,2]*, Anh Duc Nguyen[2], Toan Thanh Thi Do[1], Hung Dinh Kieu[1,3]

1. Hanoi Medical University, Hanoi, Vietnam.
2. Neurosurgery Department II, Viet Duc University Hospital, Hanoi, Vietnam.
3. Department of Neurosurgery and Spine Surgery, Hanoi Medical University Hospital, Hanoi, Vietnam.

Abstract

Cerebellopontine angle (CPA) meningiomas have always been a challenge for neurosurgeons in optimal treatment. The aim of this study is to discuss CPA meningiomas – clinical manifestations, radiological presentations and surgical results in Vietnam.

Prospective analysis was performed in 34 patients with CPA meningiomas at Neurosurgery Center of Viet Duc Hospital, Hanoi, Vietnam from August 2020 to May 2022.

There were 34 CPA meningiomas, including 29 women and 5 men with a mean age of 56 years (range 32-82 years). The main symptoms are headache (67.6%), ataxia (35.3%), vertigo (35.3%) and tinnitus (26.5%) with a mean duration of symptoms of 9 months. The patient underwent surgical treatment via retrosigmoid approach (79%), presigmoid approach (5.9%), anterior petrosectomy approach (11.8%) and the combined approach (2.9%). According to the anatomical relationship with the internal auditory canal (IAC), CPA meningiomas were classified in premeatal (20.6%), supreameatal (23.5%), inframeatal (5.9%) and retromeatal group (50%), of whom 7 cases had an IAC extension. The mean tumor size was 3.7 cm (range 1.5-6.4 cm). There were 24 cases of brainstem compression (70.6%) but only 6 cases of preoperative hydrocephalus (17.6%). Gross-total resection rate is 67%, in which retromeatal is 82.4%, premeatal is 57.1%, inframeatal is 50%, and suprameatal group is 62.5%. The rate of facial nerve preservation is 70%. There were no postoperative cerebrospinal fluid leakage and mortality.

Clinical manifestations and surgical outcomes are different among CPA meningiomas groups. Retromeatal meningiomas had better tumor removal results than the other groups. The principle of surgery is to remove the tumor as much as possible while preserving nerve function.

Clinical article (J Int Dent Med Res 2022; 15(4): 1710-1717)

Keywords: Cerebellopontine angle, meningioma, microsurgery, facial nerve function.

Received date: 20 September 2022 **Accept date:** 14 October 2022

Introduction

Meningiomas are the tumors derived from meningeal epithelial cells located in arachnoid granules. Most are benign, slow-growing tumors, commonly found in intracranial tumors of the central nervous system, representing 36% of all intracranial tumors and 2.8% in children. [1] Meningiomas are the second most common tumor in the cerebellopontine angle (CPA), accounting for 6–15% of CPA tumors and 40–42% of posterior fossa meningiomas.[2-5]

*Corresponding author:
Duy Pham, Hung Dinh Kieu
Hanoi Medical University, Hanoi, Vietnam.
E-mail: phamduy@hmu.edu.vn

Meningiomas of this region pose many surgical challenges due to their deep location, increased vascular proliferation, and compression of important neurovascular structures. [6, 7] Tumors can invade the internal auditory canal (IAC) and the foramen of the jugular vein, change the structure of the skull base, and compress the cranial nerves (CNs) and brain stem. The surgical strategy is to maximize tumor resection and to preserve facial and vestibular-cochlear nerve function when the tumor is attached to this nervous system. Depending on the characteristics of each tumor, including the location of the tumor relative to the inner ear canal (IAC), the extent of tumor expansion, there are different surgical strategies and results.[3,8,9]

In this study, we report our microsurgery experience with CPA meningiomas including

clinical signs, radiological findings, tumor resection results and influencing factors to postoperative neurologic function.

Materials and methods

Subjects

The prospective study was carried out at the Center of Neurosurgery, Viet Duc University Hospital from August 2020 to May 2022. All patients were evaluated for clinical presentations, preoperative magnetic resonance images (MRI) and underwent microsurgery for tumor resection, MRI within 6 months postoperative and histopathological result was meningioma. We excluded patients with a history of CPA meningiomas surgery or radiation therapy and patients with neurofibromatosis type 2.

Data collection

Patients were clinically examined before surgery. The age of the patient was determined at the time of surgery. Hearing was determined by postoperative hearing or clinical examination or patient description. Tumor data were collected on pre- and post-operative MRI, including T1 and T2 with/without contrast injection. Gross-total resection (GTR) was confirmed intraoperatively and based on the results of postoperative MRI within 6 months.

Data processing

All data were collected and checked for accuracy prior to statistical analysis. All descriptive and statistical analysis was performed using SPSS 24 software. Values with $p<0.05$ were considered statistically significant.

Results

Patient and Tumors Characteristics

A total of 34 patients underwent microsurgery for CPA meningiomas. Average age is 56.7±10 years (range 32 - 82), the majority of patients were female (85%). Most tumors were WHO grade I (91.2%), the remaining were grade II, including epithelial (n=12), fibrous (n=11), transitional (n=6), fibrous (n=11), angiomatous (n=2), atypical (n=3). There was no grade III. The average tumor size is 3.7±1.2 cm (range 1.5 - 6.4 cm) (Table 1)

Characteristic	Result
Number of patients	34
Age (years±SD) Range	56.7±10 32-82
Gender Male Female	 5 (14.7%) 29 (85.3%)
WHO grade I II	 31 (91.2%) 3 (8.8%)
Tumor size (cm) Mean±SD Range	 3.7±1.2 1.5-6.4

Table 1. Characteristics of 34 patients with CPA meningiomas.

Clinical Presentations

The clinical presentations are summarized in Table 2. The median duration of symptoms was 9 months (range 0.25-48 months). In our study, the most common presenting symptoms were headache (67.6%), ataxia (35.3%), vertigo (35.3%) and tinnitus (26.5%). Other presenting symptoms included hearing loss, facial numbness/pain, facial weakness, and dysphagia. All 5 cases of preoperative facial numbness/pain originated from tumors located anteriorly (n=2) and superiorly (n=3) to the IAC.

Clinical Presentation	No. patients	%
Headache	23	67.6
Ataxia	12	35.3
Vertigo	12	35.3
Tinnitus	9	26.5
Facial pain/numbness	5	14.7
Hearing loss	3	8.8
Dysphagia	3	8.8
Facial weakness	1	2.9
Accidental	1	2.9
Duration of symptoms (months) Median Range	 9 0.25-48	

Table 2. Clinical presentations of 34 patients with CPA meningiomas.

Radiological Presentation

The right tumor position (n=20) accounted for 59%, the left (n=14) accounted for 41%. Classification of tumors in relation to the IAC includes anterior to IAC (n=7) 20.6%, superior to

IAC (n=8) 23.5%, inferior to IAC (n=2) 5.9% and posterior to IAC (n) = 17) 50%, of which 7 cases (20.6%) tumor invaded the IAC and 1 case spread into the jugular vein. No patient required preoperative embolization.

The arachnoid plane appeared in 27 cases (79.4%), and the dura tail was found in 15 cases (44.1%). There were 24 cases of brainstem compression (70.6%) but only 6 cases of preoperative hydrocephalus (17.6%) and all were caused by a meningioma tumor compressing the brain stem leading to fourth ventricle obstruction. On T1-weighted MRI, the tumor was isointense in 20 cases (58.8%) and hypointense in 13 cases (58.8%). On T2-weighted MRI, most tumors are hyperintense (n=27) 79.4%. Most of the tumors were contrast-enhanced (n=32) 94%.

Treatment results

In our study, no patient required preoperative embolization. The most frequent surgical approach is retrosigmoid (79.4%). Other approach includes the presigmoid (5.9%), anterior petrosectomy (11.8%) and the combined approach (2.9%). Gross-total resection (GTR) was achieved in 24 cases (70.6%).

Characteristic	Value
Surgical approach	
- Retrosigmoid	27 (79.4%)
- Presigmoid retrolabyrinthine	2 (5.9%)
- Anterior petrosectomy	4 (11.8%)
- Combined approach	1 (2.9%)
Extent of resection	
- GTR	24 (67.6%)
- STR	10 (29.4%)
Post-operative complications	
New CN dysfunction	
- III	2 (5.9%)
- V	2 (5.9%)
- VI	3 (8.8%)
- VII	4 (11.8%)
- VIII	1 (2.9%)
Hematoma	2 (5.9%)
Pseudomenigocele	1 (2.9%)
CSF leak	0
Wound infection	0
Death	0

Table 3. Results of treatment of 34 cases of CPA meningiomas.

The most common postoperative complication was new cranial nerve (CN) deficit in 35,3% of patients, of which CN VII dysfunction accounted for the highest proportion (11.8%), followed by CN VI (8.8%), CN III and V (5.9%), CN VIII (2.9%) (Table 3). There were 3 cases of CN VII palsy grade II base on the House-Brackmann grading system, all recovered completely after 3 months, and 1 case of CN VIII deficit led to irreversible hearing loss after surgery. There were 2 cases (5.9%) of hematoma at the CPA which were successfully treated conservatively without surgical removal of the hematoma. There was 1 case (2.9%) of pseudomeningocele showing subcutaneous accumulation of cerebrospinal fluid (CSF), successful treated with Acetazolamide within 1 week. We did not encounter any cases of postoperative cerebrospinal fluid leakage and hydrocephalus.

Discussion

Clinical Presentations

The clinical symptoms of CPA meningiomas are related to CN compression, mass effect on the cerebellum and brainstem, increased intracranial pressure, and hydrocephalus. In our study, the most common symptoms were headache (67.6%), ataxia (35.3%), vertigo (35.3%) and tinnitus (26.5%). Hearing loss was found in 3 patients, we believe that meningiomas mainly compress the CN VIII and do not originate from the CN VIII as schwannomas, so the rate of hearing loss is lower than that of the schwannomas. [10] The origin and location of the meningioma determine the clinical presentation. Premeatal and retromeatal meningiomas have different clinical manifestations and symptoms.[2,4,8,11]

In our study, all patients with facial pain and numbness had meningioma originating superior to the IAC. These tumors directly compress CN V posteriorly or inferiorly, thereby causing the symptoms of the face. There were 3 patients presenting pre-operative dysphagia, in which 1 case tumor spreading into the jugular foramen, the remaining 2 cases were located posterior to the IAC with a large size of approximately 6 cm, spreading close to the jugular foramen and compressing the IX-X-XI complex intraoperatively. There were 6 cases (17.6%) of preoperative hydrocephalus, all of which were large tumors (>5 cm), compressing the brain stem causing dilation of the ventricular system. In which, there are 2 cases of decreased

consciousness, acute dilated ventricles, needing to drain the abdomen before removing the tumor. In some studies, hydrocephalus may occur in 20–31% and is more frequent in large meningiomas.[10,12]

Radiological Presentations

In the CPA region, schwannomas and meningiomas are the two most frequent lesions, accounting for 85-90%, of which schwannomas is the most common lesion accounting for 80%, while meningiomas account for 10-15%[13-18]. Based on clinical symptoms alone, it is difficult to distinguish between schwannomas and meningiomas of CPA. Diagnostic imaging with many signs helps distinguish these tumors. [6, 19, 20] Meningiomas often have wide attachment sites to the petrous bone or tentorium, forming an obtuse angle between the tumor and the petrous bone, the IAC is not enlarged. In contrast, schwannomas is concentrated in the IAC and often extends into the IAC, forming an acute angle with the petrous bone. In addition, calcification is more common in meningiomas. The rate of dural tail sign in our study was 44.1%. The dural tail sign, although not specific, is suggestive of meningiomas. Some tumors that can also have dural tail sign are metastatic tumors, lymphomas, granulomatous diseases, solitary fibromas, hemangiopericytomas that attach to the dura.[21]

Meningiomas have variable dural attachment sites and growth directions, creating heterogeneity in clinical presentation and also challenging tumor classification and surgery. Al-Mefty et al [22] divide CPA meningiomas into 2 main groups depending on the location of the tumor: anterior and posterior to the IAC. This classification has surgical and prognostic significance, the more medial to the midline, the more difficult to surgery and the worse post-operative outcome. Nakamura[8] and Bassiouni[23] further divided into 5 subgroups: anterior, posterior, superior, inferior and center to the IAC. Samii et al[2] add type of extension including Meckel's fossa, foramen magnum, IAC, and suprasellar region. Kunii and al [24] divided into 4 types: 1) tentorial type (tumor is attached from the tentorium to the anterior petrous bone, and CN V is displaced medially or caudally), 2) petroclival type (tumor is medial to CN V which is displaced laterally, 3) anterior petrous type (tumor attaches to anterior petrous bone or Meckel's cave, and the CN V is displaced rostrally or medially) and 4) posterior petrous type (tumor attaches posterior to the IAC). In our study, we use Nakamura[8] and Bassiouni[23] classification. Based on the preoperative MRI, we determined the tumor position relative to the IAC, and we could have a surgical strategy as well as choose an appropriate surgical apprach. This dertemination also helps to predict the tumor position relative to the VII-VIII complex, from which the surgeon can actively remove the tumor and improve the ability to preserve this complex. In some cases, the tumor is very large, occupies the entire CPA or grows en plaque, the determination of the tumor location should be based on the intra-operative location of the dura attachment as well as the type of CN displace.

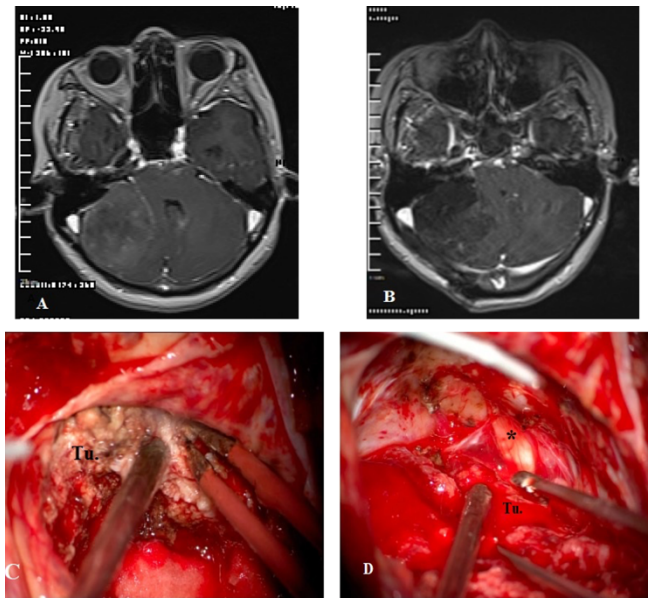

Figure 1. A preoperative axial T1-weighted Gd-enhanced MRI (A) demonstrate a CPA meningioma posterior to the IAC. A postoperative axial T1-weighted Gd-enhanced MRI (B) revealing gross-total resection of the tumor via the retrosigmoid approach. Intra-operative images demonstrate the process of internal decompression (C) and dissecting the anterior capsule of the tumor from the facial nerve (D). The VII-VIII complex appears at the end of the tumor removal. Tu. Tumor, * VII-VIII complex.

Surgical Results

There are various approaches employed to remove CPA meningiomas, including transpetrosal approaches (anterior petrosectomy, presigmoid, translabyrinthine, transcochlear approach), retrosigmoid approach, and

comnbined approach.[2,25-30] Our study used 4 approaches: retrosigmoid (79.4%), presigmoid (5.9%), anterior petrosectomy (11.8%) and combined approach (2.9%). Most CPA meningiomas can be removed using a retrosigmoid approach, especially with retromeal meningiomas. For petroclival menigiomas with a supratentorial extension in the middle cranial fossa, we used an anterior petrosectomy approach. For tumors located anterior to the IAC and extending inferior to the IAC, we applied presigmoid approach. For tumors located inferior to the IAC, even spreading into the foramen magnum, we apply retrosigmoid approach or the lateral suboccipital approach, which can combine the opening of the foramen magnum and C1 hemilaminectomy. There was 1 case where we applied to the combined approach for a large petroclival meningioma located both superior and inferior to the tentorium. In our study, the use of translabyrinthine and transcochlear approach is not recommended because these approaches destroy the petrous bone and cannot preserve hearing function as well as the risk of CSF leak, intra-operative VII-VIII complex deficit.

In our study, the GTR reached 67.6% (n=24), in which the large tumor group (> 3 cm) had the total tumor removal rate of 66.7%. Although large CPA meningiomas always pose many surgical challenges and are associated with a high rate of complication. [7, 31, 32] Our study did not find a statistically significant relationship between the extent of tumor resection and the size of tumors (Phi and Cramer's test, p=0.437). We found that with the support of modern tumor removal equipment such as surgical microscope, the ultrasonic aspirator system as well as the experience of the surgeon, along with the planning of the appropriate approach, the tumor removal rate has been greatly improved even with large tumors. The tumor removal capacity was highest in the retromeatal group 82.4% (n=14), this rate was higher than the other groups (the premetal 57.1%, inframeatal 50% and suprameatal group 62.5%). We found the ability to remove all the tumor in the retromeatal meningioma is more advantageous. Tumors in this location often displace the VII-VIII complex anteriorly (63%) or inferiorly (25%). [2] Through the retrosigmoid approach, the tumor will have first access and can be safely debulked. The CN will be visible at the end of the tumor removal process, so during the debulking process, the anterior capsule of the tumor must not be perforated, thus avoiding damage to the VII-VIII complex (Fig. 1). However, premeatal meningiomas often displace the VII-VIII complex posteriorly (45%) or inferiorly (43%)[8]. The process of dissecting this tumor through the retrosigmoid approach is often difficult because the access to the tumor is deep, and all CN block the access. In this case, the lower CNs, VII-VIII complex, are usually located posterior to the tumor capsule or sometimes within the tumor. The trigeminal nerve is usually displaced to the superior pole of the tumor, and CN VI is located most deeply anterior to the tumor. CN IV runs along the free edge of the tentorium.[27]

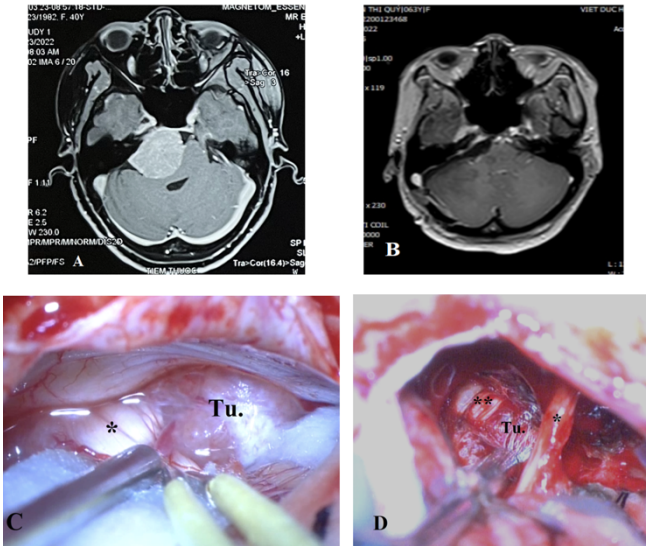

Figure 2. A preoperative axial T1-weighted Gd-enhanced MRI (A) revealing a CPA meningioma anterior to the IAC. A postoperative axial T1-weighted Gd-enhanced MRI (B) demonstrate total resection of the tumor via the retrosigmoid approach. Intra-operatively, the tumor displaced the facial nerve posteriorly (C) and the process of tumor removing through the level between the CN V and VII-VIII (D). Tu. Tumor, * VII-VIII complex, ** CN V.

The tumor will be removed through the levels between the cranial nerves (Fig. 2) : the upper level between the tentorium and CN V, the second level between CN V and the VII-VIII complex, the third level between the VII-VIII complex and the lower CNs, the lowest level between the lower CNs and foramen magnum. [2, 27] Tumor removal of premeatal meningiomas requires a good ultrasonic aspiration system to be able to aspirate each piece of tumor through

the CN levels, and it is necessary to have surgical skills to avoid damage to the CNs. All cases that could not be completely removed were due to tumor invasion of petrous bone, CNs infiltration, tumor spreading into Meckel's cave, cavernous sinus and jugular foramen. The rate of total tumor removal is now reduced to 20 - 40% according to many recent studies[33-36] for premeatal meningiomas in the petroclival region, and many authors advocate sub-total tumor removal combined with post-operative radiosurgery with 10 years progression-free survival around 80%. [34,35,37]

We have not seen any cases of postoperative CSF leakage although this is a common complication with an estimated rate of 5 to 15%[38]. We actively used the cranial fascia to patch the dura at the end of the operation with Prolene 5/0 suture and reinforced with bio-glue if necessary. There was 1 case of pseudomenigocele with fluid accumulation under the scalp, treated with Acetazolamide 250 mg x 4 tablets/day for 1 week, the patient has fully recovered. There were 2 cases of surgical site hematoma but did not require surgery, the hematoma resolved after 1 month and did not leave any complications. We carefully stopped the bleeding of the cerebellum and dura where the tumor was located at the end of surgery and tried to preserve as much as possible the large draining veins in the posterior fossa. Increase blood pressure to normal and finally the anesthesiologist presses the jugular vein before closing the dura to expose the bleeding spots.[27]

Our study found that pre-operative facial paralysis was a rare sign (2.9%) even for large tumors or tumors spreading into the IAC. CN VII can be preserved because it is generally separated from the tumor surface by the arachnoid plane. The process of dissecting the tumor capsule from the cranial nerve according to the arachnoid plane will improve the possibility of preserving the nerve. The rate of preservation of CN VII in this study reached 70.5% (n=24). Premeatal meningiomas have a lower ability to preserve facial and auditory nerve functions[4]. Schaller et al[11] reported that post-operative facial nerve function in premeatal meningiomas was worse than in the retromeatal group. Voss et al[6] reported postoperative facial nerve paresis in 60% of tumors anterior to the IAC, in 50% of tumors originated inferior to the IAC, and in less than 15% of tumors either posteriorly or superiorly. Nakamura et al[8] reported the highest ability to preserve facial nerve in meningiomas posterior to the IAC (90%) and the lowest in meningiomas anterior to the IAC (76.3%). Similar to the above results, our study has 10 patients (29.4%) with worse facial nerve function post-operative, in which 8 patients with meningioma anterior and superior to the IAC, only 2 cases with meningioma posterior to the IAC. In these 10 cases, 7 patients with poor facial nerve function had large tumors > 3 cm. According to Agarwal, [7] postoperative CN dysfunction complications were significantly different between the tumor group > 3 cm and < 3 cm (p=0.011). For large CPA tumors, if there is not enough tumor debulking, it will be difficult to dissect the CN complexes from the tumor capsule, thereby easily leading to intra-operative CN damage. We have 3 cases of post-operative CN VII paresis grade II (House-Brackmann grade), all recovered completely after 3 months, these are all cases where the CN VII was preserved during surgery but the process of removing the tumor capsule from the nerve causes temporary facial paresis. Late facial paralysis occurs in a small percentage of patients, possibly from day 14 post-operatively. Short-term steroid treatment usually improves.[39]

In this study, there were no cases requiring postoperative embolization. Because many CPA tumors receive their blood supply from branches of the meningohypophysial trunk, preoperative embolization cannot be performed. Currently in our study, the residual tumor cases have not applied adjuvant treatment. Many studies have reported that radiotherapy is an effective therapy of controlling skull base meningiomas. [40-43] We will continue to study the efficacy of this therapy in the future.

Conclusions

CPA meningiomas are the second most common lesions in the CPA region, following schwannomas. Clinically, the symptoms of meningiomas are related to cranial nerve compression, cerebellum and brainstem compression, increased intracranial pressure and hydrocephalus. MRI is used to distinguish meningiomas from other lesions in the CPA region, especially schwannomas. Furthermore, MRI can assess the size, location and extent of the tumor, helping to select the appropriate approach. Gross-total resection reached 67.6%

and the rate of facial nerve preservation was 70.5%. The rate of preservation of the facial nerve was lower in the group of suprameatal and premeatal meningiomas. We recommend removing as much of the tumor as possible but leaving a small part of the tumor, especially in the premeatal meningiomas.

Acknowledgements

Authors would like to thank Viet Duc University Hospital and Hanoi Medical University, Hanoi, Vietnam for the support for the conduction of this research.

Declaration of Interest

The authors report no conflict of interest.

References

1. Dolecek TA PJ, Stroup NE, Kruchko C. CBTRUS statistical report: primary brain and central nervous system tumors diagnosed in the United States in 2005–2009. Neuro-oncol 2012;15:1-49.
2. Samii M, Gerganov V. Surgery of Cerebellopontine Lesions. Verlag Berlin Heidelberg: Springer; 2013; 375-502.
3. Bassiouni H, Hunold A, Asgari S, Stolke D. Meningiomas of the posterior petrous bone: functional outcome after microsurgery. J Neurosurg 2004;100(6):1014-24.
4. Schaller B MA, Gratzl O, Probst R Premeatal and retromeatal cerebellopontine angle meningioma. Two distinct clinical entities. Acta Neurochir (Wien) 1999;141:465–71.
5. Anh Duc Nguyen, Nhan Le Hong, Hung Dinh Kieu. Sphenoid Wing Meningiomas: Surgical Treatment and Outcome in Viet Duc University Hospital, Vietnam. Journal of International Dental and Medical Research 2019;12(3):1222-28.
6. Voss NF VF, Heilman CB, Robertson JH Meningiomas of the cerebellopontine angle. Surg Neurol 2000;53:439–46.
7. Agarwal V, Babu R, Grier J, et al. Cerebellopontine angle meningiomas: postoperative outcomes in a modern cohort. Neurosurg Focus 2013;35(6):E10.
8. Nakamura M RF, Dormiani M, Matthies C, Vorkapic P, Samii M. Facial and cochlear nerve function after surgery of cerebellopontine angle meningiomas. Neurosurgery 2005;57:77–90.
9. Baroncini M, Thines L, Reyns N, et al. Retrosigmoid approach for meningiomas of the cerebellopontine angle: results of surgery and place of additional treatments. Acta Neurochir (Wien) 2011;153(10):1931-40; discussion 40.
10. Mallucci CL, Ward V, Carney AS, O'Donoghue GM, Robertson I. Clinical features and outcomes in patients with non-acoustic cerebellopontine angle tumours. J Neurol Neurosurg Psychiatry 1999;66(6):768-71.
11. Schaller B, Heilbronner R, Pfaltz CR, Probst RR, Gratzl O. Preoperative and postoperative auditory and facial nerve function in cerebellopontine angle meningiomas. Otolaryngol Head Neck Surg 1995;112(2):228-34.
12. Liu JK, Gottfried ON, Couldwell WT. Surgical management of posterior petrous meningiomas. Neurosurg Focus 2003;14(6):e7.
13. Chandler CL RR. Acoustic schwannoma. Br J Hosp Med 1993;49:335–43.
14. Eldridge R PD. Vestibular schwannoma (acoustic neuroma). Consensus development conference. Neurosurgery 1992;30:962–64.
15. Lanser MJ SS, Frazer K Epidemiology, pathogenesis, and genetics of acoustic tumors. Otolaryngol Clin North Am 1992;25:499–520.
16. AA Z. Cerebellopontine angle tumors: role of magnetic resonance imaging. Top Magn Reson Imaging 2000;11:98–107.
17. Barker GF OR. Surgical approaches to tumors of the posterior fossa cranial nerves (excluding acoustic neuromas). In: Barrow DL (ed) Surgery of the cranial nerves of the posterior fossa. : Park Ridge; 1993; 289-306.
18. Brackmann DE BL. Rare tumors of the cerebellopontine angle. Otolaryngol Head Neck Surg 1980;88:555–9.
19. Wilms G PC, Goossens L, Goffin J, Vanwambeke K. The radiological differentiation of acoustic neuroma and meningioma occurring together in the cerebellopontine angle. Neurosurgery 1992;30:443-45.
20. Bonneville F SJ, Chiras J Imaging of cerebellopontine angle lesions: an update. Part 2: intra-axial lesions, skull base lesions that may invade the CPA region, and non-enhancing extra-axial lesions. Eur Radiol 2007;17:2908–20.
21. EW W. The dural tail sign. Radiology 2004;233:56–57.
22. Franco DeMonte MWM, Ossama Al-Mefty. Al-Mefty's Meningiomas. 2nd ed. New York - Stuttgart: Thieme; 2011; 262-269.
23. Bassiouni H HA, Asgari S Meningiomas of the posterior petrous bone: functional outcome after microsurgery. J Neurosurg 2004;100:1014–24.
24. Kunii N, Ota T, Kin T, et al. Angiographic classification of tumor attachment of meningiomas at the cerebellopontine angle. World Neurosurg 2011;75(1):114-21.
25. Arriaga M, Shelton C, Nassif P, Brackmann DE. Selection of surgical approaches for meningiomas affecting the temporal bone. Otolaryngol Head Neck Surg 1992;107(6 Pt 1):738-44.
26. Samii M, Tatagiba M. Experience with 36 surgical cases of petroclival meningiomas. Acta Neurochir (Wien) 1992;118(1-2):27-32.
27. Paolo Cappabianca DeS. Meningiomas of the skull base : treatment nuances in contemporary neurosurgery. Stuttgart ; New York: Thieme; 2019; 95-112.
28. Sekhar LN SN, Jaiswal V, Rubinstein E, Hirsch WE Jr, Wright DC Surgical excision of meningiomas involving the clivus: preoperative and intraoperative features as predictors of postoperative functional deterioration. J Neurosurg 1994;81:860–68.
29. Bambakidis NCM, Cliff A.; Spetzler, Robert F. Surgery of the Cerebellopontine Angle USA: People's Medical Publishing House; 2009; 53-71.
30. T Kawase RS, S Toya. Anterior transpetrosal-transtentorial approach for sphenopetroclival meningiomas: surgical method and results in 10 patients. Neurosurgery 1991;28:869-75.
31. Leonetti JP, Anderson DE, Marzo SJ, Origitano TC, Schuman R. Combined transtemporal access for large (>3 cm) meningiomas of the cerebellopontine angle. Otolaryngol Head Neck Surg 2006;134(6):949-52.
32. Xu F, Karampelas I, Megerian CA, Selman WR, Bambakidis NC. Petroclival meningiomas: an update on surgical approaches, decision making, and treatment results. Neurosurg Focus 2013;35(6):E11.
33. Abdel Aziz KM, Sanan A, van Loveren HR, et al. Petroclival meningiomas: predictive parameters for transpetrosal approaches. Neurosurgery 2000;47(1):139-50; discussion 50-2.
34. Little KM, Friedman AH, Sampson JH, Wanibuchi M, Fukushima T. Surgical management of petroclival meningiomas: defining resection goals based on risk of neurological morbidity and tumor recurrence rates in 137 patients. Neurosurgery 2005;56(3):546-59; discussion 46-59.
35. Natarajan SK, Sekhar LN, Schessel D, Morita A. Petroclival meningiomas: multimodality treatment and outcomes at long-term follow-up. Neurosurgery 2007;60(6):965-79; discussion 79-81.
36. Jung HW, Yoo H, Paek SH, Choi KS. Long-term outcome and growth rate of subtotally resected petroclival meningiomas: experience with 38 cases. Neurosurgery 2000;46(3):567-74;

discussion 74-5.
37. Hunter JB, Weaver KD, Thompson RC, Wanna GB. Petroclival meningiomas. Otolaryngol Clin North Am 2015;48(3):477-90.
38. Lars P. Translabyrinthine Approach to Vestibular Schwannomas. In: Quiñones-Hinojosa A, editor. Schmidek & Sweet Operative Neurosurgical Techniques: Indications, Methods, and Results. 6 ed. Philadelphia, PA: Elsevier Saunders; 2012. p. 555-64.
39. Pamir MN, Black PML, Fahlbusch R. Meningiomas: A Comprehensive Text: Saunders/Elsevier; 2010; 529-534.
40. Zachenhofer I, Wolfsberger S, Aichholzer M, et al. Gamma-knife radiosurgery for cranial base meningiomas: experience of tumor control, clinical course, and morbidity in a follow-up of more than 8 years. Neurosurgery 2006;58(1):28-36; discussion 28-36.
41. Subach BR, Lunsford LD, Kondziolka D, Maitz AH, Flickinger JC. Management of petroclival meningiomas by stereotactic radiosurgery. Neurosurgery 1998;42(3):437-43; discussion43-5.
42. Jahanbakhshi A, Azar M, Kazemi F, et al. Gamma Knife stereotactic radiosurgery for cerebellopontine angle meningioma. Clin Neurol Neurosurg 2019;187:105557.
43. Flannery TJ, Kano H, Lunsford LD, et al. Long-term control of petroclival meningiomas through radiosurgery. J Neurosurg 2010;112(5):957-64.