Cross-Sectional Study

ANNALS OF MEDICINE & SURGERY

OPEN

Surgical outcomes of premeatal and retromeatal cerebellopontine angle meningioma in Vietnam: a single-center prospective cross-sectional study

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Background: Cerebellopontine angle (CPA) meningiomas are the second most common tumor of the CPA. Depending on the site of dural attachment, the relationship between the tumor and critical neurovascular structures of the CPA is variable. This study aims to evaluate the influence of CPA meningioma location in relation to the internal auditory canal (IAC) on clinical symptoms, radiological presentations, and surgical treatments and outcomes which has been rarely reported in Vietnam.

Patients and methods: A prospective study on 33 patients treated with microsurgery from August 2020 to May 2022 at the Neurosurgery Center, Viet Duc University Hospital.

Results: The mean age of 27 females (85%) and 6 (15%) males was 54 ± 12 years. Based on their location to the IAC, there were 16 premeatal cases (49%) (anterior to the IAC) and 17 retromeatal cases (15%) (posterior to the IAC). The time of diagnosis of the retromeatal group was later (16.5 vs. 9.7 months), the average tumor size of the 2 groups was not different, but when there was brainstem compression, the average tumor size of retromeatal group was larger (49 vs. 44 mm). The clinical presentations of the retromeatal group were related to the cerebellar symptoms, while trigeminal neuropathy symptoms all came from the premeatal group. Gross total resection of the premeatal group was 31% and of the retrometal group was 71%. The results of preserving the facial nerve function of the premeatal group were lower (44 vs. 82%). Postoperative Karnofsky score of the retromeatal group improved, while the premeatal group did not change.

Conclusions: Classification of CPA meningiomas according to their location to the IAC plays an important role in diagnosis and treatment, affecting clinical symptoms, surgical strategy as well as surgical outcomes.

Keywords: cerebellopontine angle, meningioma, microsurgery, premeatal, retromeatal

Introduction

Meningiomas are the most common primary central nervous system tumors, accounting for approximately one-third of primary tumors in the brain and spinal cord. Meningiomas are the second most common CPA tumor, following vestibular schwannomas, representing 6–15% of CPA tumors and 40–42% of posterior fossa meningiomas[1–5]. The tumor originates from the cap cells of the arachnoid villi, which are usually located along the large venous sinuses and absorb cerebrospinal fluid (CSF). CPA meningiomas are attached to the posterior surface of the petrous bone, around the internal auditory canal (IAC), or attached to the inferior surface of the cerebellar tentorium, towards the CPA[2,3,6].

HIGHLIGHTS

- Meningiomas are the second most common tumor in the cerebellopontine angle (CPA).
- Surgical outcomes are different between premeatal and retromeatal meningiomas.
- Surgical removal of premeatal meningiomas is still a challenge for neurosurgeons.

The location of dural attachment as well as the variable direction of tumor growth and the complex involvement of neural and vascular structures make CPA meningioma a diverse clinical presentation and surgical challenge[7]. Variable attachment sites make it more difficult to predict the direction of displacement of the cranial nerves (CNs), especially of the VII–VIII complex[8].

There are many ways to classify CPA meningiomas, in which the common classification and easy to apply in clinical practice is to divide CPA meningioma into two groups: anterior (premeatal) and posterior (retromeatal) to the IAC[3,9]. In Vietnam, there are currently no studies on CPA meningiomas as well as the factors affecting the results of surgery, although CPA meningioma surgery has been performed since the late 1990s. The aim of this study is to evaluate the influence of CPA meningioma location according to the IAC on clinical symptoms, imaging, and surgical results.

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article

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Annals of Medicine & Surgery (2023) 85:1626–1632

Received 9 October 2022; Accepted 17 March 2023

Published online 7 April 2023

http://dx.doi.org/10.1097/MS9.0000000000000553

Patients and methods

This study has been reported in line with the STROCSS criteria[10] and has been registered at the Research Registry with the Unique Identifying Number: researchregistry8375.

Subject

The prospective study was carried out at the Center of Neurosurgery, Hanoi, Vietnam from August 2020 to May 2022. All patients were evaluated for clinical presentations, preoperative MRIs and underwent microsurgery for tumor resection, MRI within 6 months, the postoperative and histopathological result was a meningioma, and postoperative clinical presentation and complications were assessed. We excluded patients with previous CPA meningiomas surgery or radiation therapy and patients with neurofibromatosis type 2.

Data collection

Patients underwent clinical examination and preoperative symptom data was collected. All patients underwent preoperative and postoperative MRI, including T1 and T2 with/without contrast injection. On MRI, we collect data on tumor size, location, as well as other signs of neurological compression. All patients underwent microsurgery to remove the tumor and assessed postoperative clinical presentations and complications. The tumor was assessed as gross total removal based on tumor resection tumor extension and postoperative MRI results within 6 months confirmed no tumor.

Data processing

All data were collected and checked for accuracy before statistical analysis. All descriptive and statistical analysis was performed using SPSS 24 software. Values with P less than 0.05 were considered statistically significant.

Results

Patient and tumor characteristics

A total of 33 patients underwent microsurgery for CPA meningiomas. The majority of patients were female (85%). Most tumors were WHO grade I (87.9%), the remaining were grade II, including epithelial ($n=10$), fibrous ($n=10$), transitional ($n=8$), angiomatous ($n=1$), and atypical ($n=4$). There was no grade III. The average tumor size is 4.2 cm (Table 1).

Clinical presentations

The clinical presentations are summarized in Table 2. The mean duration of clinical presentations of the premeatal group was shorter (9.7 vs. 16.5 months). In both groups, headache, vertigo, and tinnitus were the most common symptoms. However, retromeatal group had predominantly ataxia (41 vs. 12%) and all patients with trigeminal neuralgia were in the premeatal group.

Radiological presentation

The mean tumor size of the two groups was similar (4.2 cm). However, when considering the cases with brainstem compression, premetal tumors tended to be smaller in size than retromeatal tumors (4.48 vs. 4.96 cm) and the mean duration of symptoms of premeatal group was shorter (9.7 vs. 20 months). There were seven cases of hydrocephalus without preoperative drainage (Table 3).

Table 1

Characteristics of 33 patients with cerebellopontine angle meningiomas

Characteristics	Result [*n* (%)]
Number of patients	33
Age (mean ± SD) (years)	54.1 ± 12.2
Range	32–82
Sex	
Male	6 (14.7)
Female	27 (85.3)
WHO grade	
I	29 (87.9)
II	4 (12.1)
Location	
Premeatal	16 (48.5)
Retrometal	17 (51.5)
Tumor size (cm)	
Mean ± SD	4.2 ± 1.3
Range	1.7–7.5

Result of surgery

The surgical results are summarized in Tables 4 and 5. The capacity to gross total tumor resection of premeatal meningiomas was lower (31 vs. 70%). The ability to preserve facial nerve function of retromeatal meningiomas is higher (82 vs. 43%) and the rate of postoperative CNs dysfunction of this group is lower (17 vs. 87%). We did not encounter any cases of postoperative CSF leakage, tracheostomy, and mortality.

Discussion

In terms of epidemiologic characteristics, our results show that the average age of patients is 54.1 years, with a female predominance. This result is in line with the epidemiological characteristics of CPA meningioma according to numerous reports[7,11,12]. Histopathological results of CPA meningioma of

Table 2

Preoperative clinical presentations of premeatal and retromeatal groups

	n (%)	
Clinical symptoms	Premeatal ($N=16$)	Retromeatal ($N=17$)
Mean duration of symptoms (months)	9.7	16.5
Range (months)	0.5–36	0.25–84
Hearing loss	4 (25)	2 (11.8)
Ataxia	2 (12.5)	7 (41.2)
Headache	9 (56.3)	13 (76.5)
Facial pain/numbness	4 (25)	0
Tinnitus	2 (12.5)	5 (29.4)
Vertigo	5 (31.3)	8 (47.1)
Facial weakness	0	1 (5.9)
Oculomotor nerve palsy	1 (6.3)	0
Dysphagia	1 (6.3)	1 (5.9)

Table 3

Radiological characteristics of premeatal and retromeatal groups

	n (%)	
Characteristics	**Premeatal (*N* = 16)**	**Retromeatal (*N* = 17)**
Location		
Right	12 (75)	8 (47,1)
Left	4 (25)	9 (52,9)
Size (cm)		
Mean ± SD	4.2 ± 1.3	4.2 ± 1.3
Range	1.7–7.5	2–6.4
Dural tail	13 (81.3)	5 (29.4)
Arachnoid plane	11 (68.8)	12 (70.6)
Peritumoral edema	4 (25)	6 (35.3)
Brainstem compression	14 (87.5)	11 (64.7)
Tumor size of brainstem compression group (mean ± SD) (cm)	4.48 ± 1.19	4.96 ± 0.95
Mean duration of symptoms ($P = 0.015$) (months)	9.7	20
Hydrocephalus	1 (6.3)	6 (35.3)

our study are grade I and II according to the classification of the WHO, without grade III, this result is similar to many other authors[2,12–14].

The duration from clinical presentation to diagnosis in premeatal tumors is shorter than in the retremeatal group, meaning that premeatal group is often diagnosed earlier. Schaller *et al.*[3] reported on 31 cases also gave similar results, when the average diagnosis time of retromeatal group was 1.1 years, while the retromeatal group was 2.7 years. In both groups, the most common clinical symptoms were headache, tinnitus, and vertigo.

Table 4

Surgical results of premeatal and retromeatal groups

	n (%)	
Result	**Premeatal (*n* = 16)**	**Retromeatal (*n* = 17)**
Mean duration of surgery (h)	6.5	4.2
Surgical approach		
Presigmoid retrolabyrinthine	6 (37.5)	0
Retrosigmoid	4 (25)	17 (100)
Anterior petrosectomy	6 (37.5)	0
Extent of resection		
Gross total resection	5 (31.3)	12 (70.6)
Subtotal resection	11 (62.5)	5 (29.4)
Postoperative facial nerve function		
Unchanged	7 (43.8)	14 (82.4)
Worsened	9 (56.3)	3 (15.6)
Postoperative complications		
CSF leakage	0	0
CN palsy	14 (87.5)	3 (17.6)
Hydrocephalus	0	0
Infection	0	0
Hematoma	0	1 (5.9)
Brainstem ischemia	2 (12.5)	0
Tracheostomy	0	0
Death	0	0
Karnofsky score		
Preoperation	80.6 ± 8.7	81.2 ± 7.4
3 months postoperation	78.4 ± 13.2	90.9 ± 7.9

CN, cranial nerve; CSF, cerebrospinal fluid.

Table 5

Postoperative CNs damage of premeatal and retromeatal groups

	n (%)	
Complications	**Premeatal (*N* = 16)**	**Retromeatal (*N* = 17)**
CN III	4 (25)	0
CN IV	4 (25)	0
CN V	3 (18.7)	0
CN VI	5 (31.2)	0
CN VII (House–Brackmann grade)	8 (50)	3 (17.6)
Grade II	2 (12.5)	1 (5.9)
Grade III	2 (12.5)	1 (5.9)
Grade IV	4 (25)	1 (5.9)
CN IX–XII	1 (6.2)	0

CN, cranial nerve.

Many reports show that the most common symptoms in 50–78% of cases are related to the ear: hearing loss (41–68%), vertigo (20–31%), and tinnitus (12–22%)[2,8,15,16]. However, retromeatal group showed a higher tendency to have ataxia (41 vs. 12%). This is explained by the tumor location posterior to the IAC, which directly compresses the cerebellum and causes the cerebellar syndrome more evident. All retromeatal tumors with cerebellar syndrome also decreased or resolved their symptoms 1–2 months after surgery. In contrast, all patients with symptoms of facial pain or numbness (symptoms due to CN V compression) belong to the retromeatal group. Because the CN path away from the brainstem is located anterior, premeatal meningioma will displace the CN V superiorly or medially, thereby causing trigeminal neuralgia. We have two patients with dysphagia and hoarseness due to tumor compression on the IX–XI complex, in both groups there are large tumors (6.4 and 7 cm), extending to the jugular foramen. Intraoperatively, these tumors have not invaded into the jugular foramen, but they displaced the lower CNs below the lower pole of the tumor. Kane *et al.*[12] reported that 92% of patients with lower CNs palsy have tumors invading the jugular foramen intraoperatively.

In terms of radiological presentations, the mean tumor size in both groups showed similar results (4.2 cm, $P = 0.428$, *t*-test). However, when considering the cases of brainstem compression tumors, we found that the size of premeatal tumors tended to be smaller than retromeatal group (4.48 vs. 4.96 cm) and were diagnosed earlier (9.7 vs. 20 months, $P = 0.015$, *t*-test). We found that retromeatal meningiomas can more easily compress the anterolateral side of brainstem despite its small size, resulting in early and aggressive clinical signs. Tumors posterior to the IAC in their development often compress cerebellum, and when reaching large size (> 4 cm) it compressed the posterolateral side of brainstem. Based on MRI, we determined the dural attachment location of the tumor with respect to the IAC, helping the surgeon predict the displacement of the CNs in the CPA, thereby having a strategy to remove the tumor and preserve the CNs[2]. Nakamura *et al.*[17] reported that for retromeatal meningioma, the lower CNs is often displaced anteriorly (63%) or inferiorly (25%), and for premeatal meningioma, this complex is displaced posteriorly (45%) or inferiorly (43%). Bassiouni *et al.*[2] reported finding the VII–VIII complex in the anterior aspect of retromeatal meningiomas (84%) and in the posterior (50%) and inferior (42.9%) aspect of premeatal meningiomas.

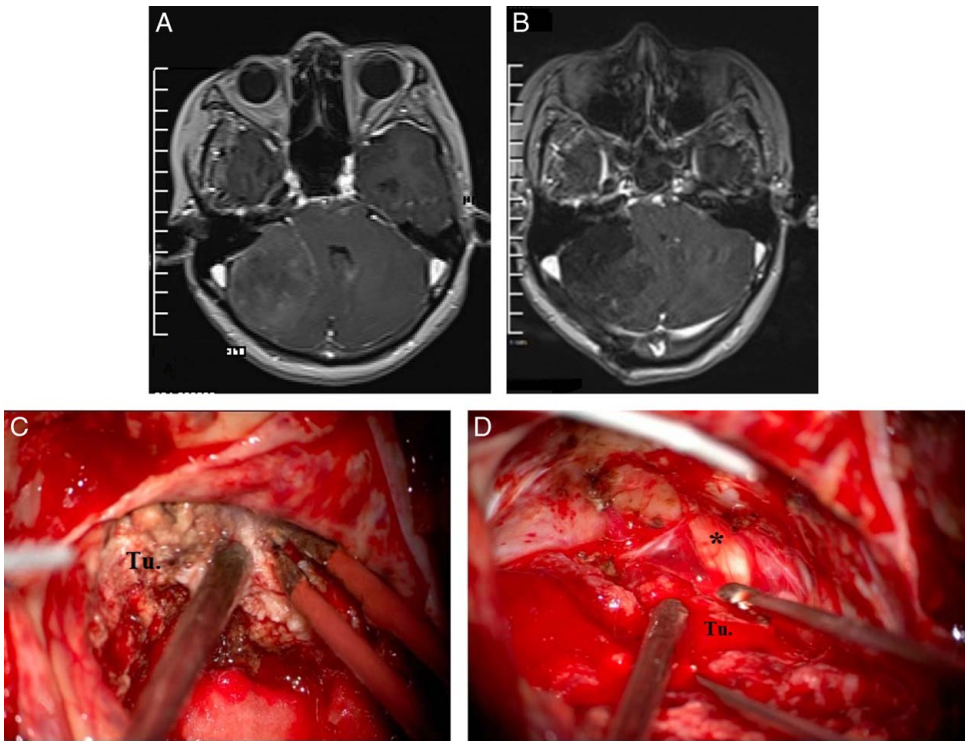

Figure 1. A preoperative axial T1-weighted gadolinium-enhanced MRI (A) demonstrate a cerebellopontine angle meningioma posterior to the internal auditory canal. A postoperative axial T1-weighted gadolinium-enhanced MRI (B) revealing gross total resection of the tumor via the retrosigmoid approach. Intraoperative images demonstrate the process of internal decompression (C) and dissecting the anterior capsule of the tumor from the facial nerve (D). The lower cranial nerves appears at the end of the tumor removal. *Lower cranial nerves. Tu, tumor.

All patients with retromeatal meningiomas were operated via the retrosigmoid approach. This approach provides a wide access for the entire posterior surface of the petrous bone, preserving the hearing function compared with the petrosectomy approach, so it is perfectly suitable for the retromeatal meningiomas[11]. However, with the premeatal group, particularly the tumor spread in the petroclival area, we need other approaches to be able to access the tumor[1,18–23]. For premeatal meningiomas in the petroclival region with a large part of the tumor spreading into the middle cranial fossa and smaller CPA part of tumor located superior to the IAC, we applied the anterior petrosectomy approach (also known as the Kawase approach[24]). For large premeatal meningiomas in the petroclival region, we applied the presigmoid approach to gain access to clivus and the anterolateral aspect of the brainstem[25]. In our study, six patients underwent a presigmoid retrolabyrinthine approach to preserve hearing since no patient suffered from a complete hearing loss, so the selected presigmoid approach was the retrolabyrinthine. The translabytinthine and transcochlear approach are not applied in case the patient still has auditory function[11]. Our study found that the extent of tumor resection depends on the approaches ($P = 0.02$, Fisher's exact test).

The surgical results of our study demonstrated that the capacity to preserve the facial nerve was lower in premeatal meningiomas than in retromeatal group (43 vs. 82%, $P = 0.047$, Fisher's exact test) and the rate of other CNs palsy in premeatal group was significantly higher. Voss *et al.*[8] reported the rate of postoperative facial dysfunction in premeatal meningiomas was 60% and retromeatal group was less than 15%. Nakamura *et al.*[17] reported preservation of the facial nerve in 76% premeatal tumors and 90% in retromeatal tumors, whereas D'Amico *et al.*[5] reported a rate of 66% in petroclival meningiomas compared with 89% of retromeatal meningiomas. The extension of tumor resection of premeatal group was also lower (31 vs. 70%), this result is similar to Wu *et al.*'s report[4] (100 vs. 75%). Our study found that the postoperative rate of other CNs damage of the premeatal group was significantly higher as well. According to Hunter *et al.*'s report[11] the rate of postoperative CN dysfunction of premeatal meningiomas in the petroclival region was 20.3–67%. We found that the meningioma anterior to the IAC, especially with spreading into the petroclival region, is a deep-located tumor, in the middle of the skull base, surrounded by the brainstem and CNs. For this group, the surgical approach to the tumor has its own disadvantages. In retrosigmoid approach, the tumor is accessed through the levels between the CNs: the uppermost level between cerebellar tentorium and the CN V, the second level between the CN V and the VII–VIII complex, the third level between the VII–VIII complex and the lower CNs, the lowest level between the lowers CNs and foramen magnum (Fig. 1). Dissecting through the narrow levels between the CNs can damage the nerve[1,20]. In contrast to the retromeatal meningiomas, the access to the tumor through the retrosigmoid approach is shallower, and the VII–VIII complex will find at the end of tumor resection in the anterior tumor capsule and can completely dissect this complex from the tumor capsule when enough tumor debulking is done (Fig. 2). Premeatal meningiomas remove are also difficult with anterior petrosectomy approach, the technique of petrosectomy is difficult, the process of opening

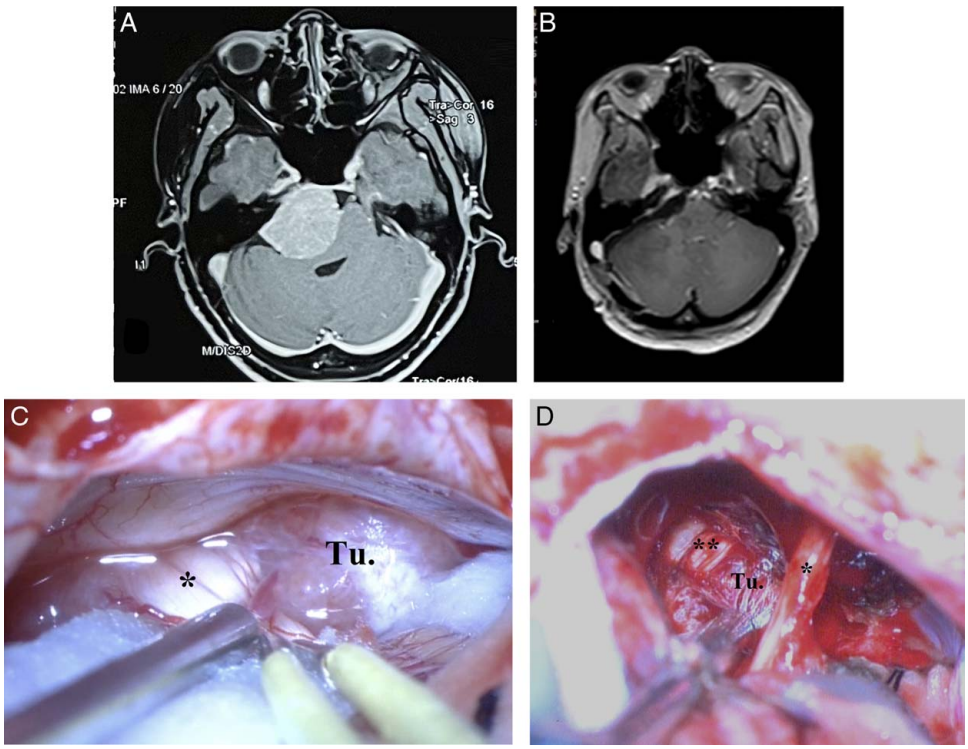

Figure 2. A preoperative axial T1-weighted gadolinium-enhanced MRI (A) revealing a cerebellopontine angle meningioma anterior to the internal auditory canal. A postoperative axial T1-weighted gadolinium-enhanced MRI (B) demonstrate total resection of the tumor via the retrosigmoid approach. Intraoperatively, the tumor displaced the facial nerve posteriorly (C) and the process of tumor removal through the level between the cranial nerve V and VII–VIII (D). *VII–VIII complex, **cranial nerve V. Tu, tumor.

the cerebellar tentorium to access the tumor in the CPA can damage the CN III, IV, VI. Premeatal meningiomas resection via presigmoid approach are complicated in terms of bone drill techniques, the high risk of damage to the VII–VIII complex during process of petrous drill, the risk of CSF leakage and brainstem and vascular damage during tumor dissection. We encoutered two patients with hemiplegia following premeatal tumor resection, both were large tumors spreading into the petroclivus, the arachnoid plane disappeared between the tumor and postoperative MRI demonstrated the ischemia of part of brainstem. Wu *et al.*[4] reported that the rate of postoperative hemiplegia in premeatal group was 5/32 cases, whereas in retromeatal group there were no cases.

Classification of CPA meningiomas into two groups: anterior and posterior to the IAC is simple and easy to apply in clinical practice, but in fact, there are CPA meningiomas located in the intermediate position and invading into the IAC. Therefore, we propose to apply classification of Desgeorges and Sterkers[26] and Sanna *et al.*[27] in these cases. They divided posterior petrous face meningiomas into three types: type A (anterior) tumors originating between the trigeminal and the anterior border of the IAC, and type M (middle) tumors originating around the IAC, type P (posterior) tumor develops from the labyrinth posteriorly to the sigmoid sinus. According to this classification, type M corresponds to the group of meningiomas whose main body is located in the IAC and can invade the IAC. In our study, regardless of whether the tumor is located anterior or posterior the IAC if the tumor invades the IAC, it affects the auditory function with statistical significance ($P = 0.034$, Fisher's exact test). The extension of tumor resection was also significantly related to the invasion of the IAC ($P < 0.05$, Fisher's exact test). Therefore, we also recommend considering the invasion of the IAC before the surgery. Some cases of large meningiomas or tumors that develop en plaque on the whole posterior surface of the petrous bone both anterior and posterior to the IAC, it is difficult to locate the tumor on preoperative MRI. We evaluate the location of tumor attachment as well as the location of the CNs intraoperatively to accurately classify the tumor location. We also recommend the application of Peyre and Sanna's classification[27,28]. They added several intermediate types including: AM, MP, AMP based on the extension of tumor and invasion of the IAC.

Applying the Wilcoxon test to compare mean Karnofsky scores before the operation and 3 months after the operation gives the following results: There was no difference in premeatal meningiomas ($P = 0.69$), while in retromeatal meningiomas there was a statistically significant difference ($P = 0.001$). This means that surgical resection of the tumor actually improved the Karnofsky score of retromeatal group but did not make a difference in premeatal group. Applying the Mann–Whitney test to compare the mean Karnofsky scores of the two groups gives the following results: There was no difference in preoperative Karnofsky score of the two groups ($P = 0.98$), however, postoperative Karnofsky score in retromeatal group was higher than in premeatal group ($P = 0.001$). It proves that the surgical outcomes of retromeatal group are better than premeatal according to our study. Because of the challenge in the capacity to gross total resection and the postoperative complications are still high, the patient's postoperative quality of life is not greatly improved

despite the attempt to remove the entire tumor, some authors tend to remove subtotal of tumor with postoperative radiotherapy with 10-year progression-free survival about 80% for premeatal tumors extending to petroclivus[11,29,30].

The strength of our study is that there are two groups of CPA meningioma patients with an equal number, which underwent microsurgery for tumor resection at a single neurosurgery center by the same surgical team within 1.5 years. However, the limitation of the study is that the follow-up time is short period and number of patients is limited. Further large-scale studies may be planned to improve research validity and reliability.

Conclusions

The location of dural attachment in relation to the IAC has an important role in diagnosis and treatment, affecting clinical symptoms, surgical strategies, and outcomes. Our study demonstrated that despite being diagnosed earlier, the postoperative neurological function results of premeatal meningiomas were worse than those of retromeatal group. Surgical removal of premeatal meningiomas is still a challenge for neurosurgeons due to their deep location and involvement of critical neurovascular structures. This study will continue to assess the long-term postoperative outcomes of these two groups of meningiomas.

Ethical approval

This study was approved by Ethics Committee at Hanoi Medical University no: 484/GCN-HĐĐĐNCYSH-ĐHYHN.

Consent

Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Sources of funding

This is a nonfunded study.

Conflicts of interest disclosure

The authors declare that they have no financial conflict of interest with regard to the content of this report.

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Guarantor

Duy Pham.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Acknowledgements

None.

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