Angiographic Classification of Tumor Attachment of Meningiomas at the Cerebellopontine Angle

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Key words
- Angiography
- Attachment
- Cerebellopontine angle
- Classification
- Meningioma

Abbreviations and Acronyms
CI: Confidence interval
CPA: Cerebellopontine angle
CTA: Computed tomography angiography
ICA: Internal carotid artery
MRA: Magnetic resonance angiography
MRI: Magnetic resonance imaging
WHO: World Health Organization

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OBJECTIVE: **To present an angiographic classification of attachment of meningiomas at the cerebellopontine angle (CPA) based on tumor feeding and to validate the utility of this classification in predicting meningioma attachments at the CPA.**

METHODS: **The authors retrospectively analyzed 34 consecutive patients with meningioma at the CPA. Based on operative findings, tumors were classified into four types: the petroclival type, in which the trigeminal nerve is displaced laterally; the tentorial type, in which the center of tumor attachment is located at the medial tentorium; the anterior petrous type, in which the center of tumor attachment is located anterior to the meatus; and the posterior petrous type, in which the center of tumor attachment is located posterior to the meatus. Magnetic resonance imaging (MRI) was sufficient to confirm attachment of the posterior petrous type. Another 26 cases were analyzed angiographically and classified into three types: abnormal ipsilateral tentorial artery type (type A); bilateral internal carotid artery (ICA) type (type B); and nontentorial, non-ICA type (type N). This angiographic classification was validated by comparison with the attachment classification.**

RESULTS: **Angiographic types A, B, and N corresponded to tentorial, petroclival, and anterior petrous types of attachment. Observed agreement was very high, particularly for tumors greater than 30 mm in diameter (κ statistic 0.83; 95% confidence interval [CI] 0.62–1.0). Angiographic type in this paired attachment typing offered high sensitivity and specificity greater than 0.80 in tumors larger than 30 mm.**

CONCLUSIONS: **This angiographic classification seems to be useful in predicting meningioma attachments at the CPA. The existence of an abnormally developed tentorial artery seems highly indicative of tumor attachment to the tentorium.**

INTRODUCTION

Although advances in skull base techniques have dramatically decreased mortality and morbidity associated with resection of meningiomas at the cerebellopontine angle (CPA), surgery for this region remains challenging (2, 3, 11, 18, 25, 28). Other than advances in operative techniques, there are two major factors that are expected to promote further improvement in the operative outcome. One is preoperative knowledge of the consistency and the World Health Organization (WHO) grading of the lesion. In the last 2 decades, a high correlation has been shown between hyperintensity of meningioma on T2-weighted magnetic resonance imaging (MRI) and soft consistency of the tumor, which is sometimes associated with WHO high grade or high vascularity (4, 19, 29, 30, 33). Knowing these characteristics of the tumor could greatly influence extent of craniotomy, estimation of operative time, and risk-benefit assessment. The other factor is preoperative knowledge of tumor attachment, which is of greater importance than the former factor, especially in this difficult location, because knowledge of tumor attachment not only has a strong influence on the above-mentioned preoperative evaluations but also might change the operative approach itself.

To investigate surgical approaches in greater detail, numerous surgeons have proposed various attachment classifications for meningioma at the CPA (3, 16, 20, 26, 27, 32). Based on intraoperative findings, Al-Mefty (1) classified posterior fossa meningiomas into six subtypes: petroclival, sphenopetroclival, clival, foramen magnum, anterior petrosal, and posterior petrosal. Petroclival meningiomas are defined as arising from the upper two thirds of the clivus, at the petroclival junction, and medial to the trigeminal nerve. Such tumors often span the middle and posterior cranial fossae and can involve the posterior cavernous sinus through Meckel cave. Sphenope-

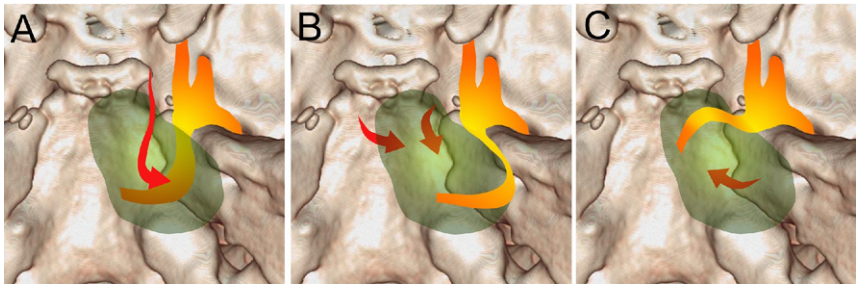

Figure 1. Schematic illustration of tumoral attachment and direction of trigeminal nerve displacement. **(A)** Trigeminal nerve is displaced caudally by tumor attached to tentorium (tentorial type). **(B)** Trigeminal nerve is displaced laterally by tumor attached to petroclival dura (petroclival type). **(C)** Trigeminal nerve is displaced rostrally by tumor attached to anterior petrous dura (anterior petrous type). Red arrows indicate the putative vascular supply of each attachment type.

troclival meningiomas are more extensive, involving the anterior cavernous sinus, invading the sella turcica and sphenoid sinus, and occasionally involving bilateral cavernous sinuses. Tumors arising from the midline clivus and displacing the brainstem and basilar artery posteriorly are defined as clival meningiomas, whereas tumors arising from the lower third of the clivus are defined as foramen magnum meningiomas. Posterior fossa meningiomas arising lateral to the trigeminal nerve are called petrosal meningiomas and are split into anterior and posterior petrosal meningiomas (1, 8). Tentorial meningiomas were not included in Al-Mefty's classification.

Operative mortality is increased mainly in association with cranial nerve injuries. To preserve the cranial nerves, the surgical field must be kept as bloodless as possible, and the cranial nerves need to be kept clear during surgical manipulation, even if deformed by the tumor. For this purpose, coagulating the feeding artery at the tumor attachment in the early stages of tumor resection is quite useful. A clear understanding of the relationship between the tumor attachment of the meningioma at the CPA and the cranial nerves is very important, particularly for the trigeminal nerve, because such knowledge can dramatically improve the speed and safety of the coagulation process. Meningiomas at the CPA usually grow slowly and have become large by the time of diagnosis, however, and are in contact with numerous surrounding neural, vascular, and bony structures. Knowing the precise location of the tumor attachment is sometimes difficult based on preoperative MRI alone (6, 14).

Cerebral angiography can be used to show the attachments of meningiomas because the vascular supply of these lesions comes from the normal dural arteries that supply the site of tumor attachment. Such arteries usually penetrate the meningioma peripherally and then develop an extensive arterial and capillary network in the center of the tumor (13), indicating that the feeding artery is well localized to the tumor attachment. With this concept, we hypothesized that angiographic classification corresponds to attachment classification and can be used to predict tumor attachment before surgery. The purpose of this study was to validate this hypothesis by retrospectively analyzing 34 cases of meningioma at the CPA treated surgically in our hospital.

METHODS

We studied 34 consecutive patients with meningioma at the CPA who underwent surgery at The University of Tokyo Hospital between November 2001 and April 2009. We included all meningiomas that extended into the CPA along the petroclival fissure or around the internal auditory meatus. We did not include meningiomas with obvious attachment to the lower clivus, jugular foramen, or foramen magnum or tentorial meningiomas unrelated to the CPA. Cases with previous surgical treatment were excluded because considerable alterations to tumor feeding would be present owing to the first operation. Mean age was 52 years (range 22–80 years), and the male-to-female ratio was 1:3 (9 men, 25 women). All study protocols were approved by the institutional review board.

Classification of the Attachment

Based on the operative records, attachment of the meningioma was classified into four types: tentorial, petroclival, anterior petrous, and posterior petrous. Tentorial type ($n = 13$) describes tumors attached to the dura mater from the tentorium to the anterior petrous bone. The trigeminal nerve is displaced caudally or medially. Petroclival type ($n = 7$) categorizes tumors attached medial to the trigeminal nerve. The trigeminal nerve is displaced laterally and is sometimes involved in the tumor. Anterior petrous type ($n = 6$) includes tumors arising from the dura mater of the anterior petrous bone or Meckel cave. The trigeminal nerve is displaced rostrally or medially. Posterior petrous type ($n = 8$) includes tumors with attachments that are posterior to the internal auditory meatus (including the

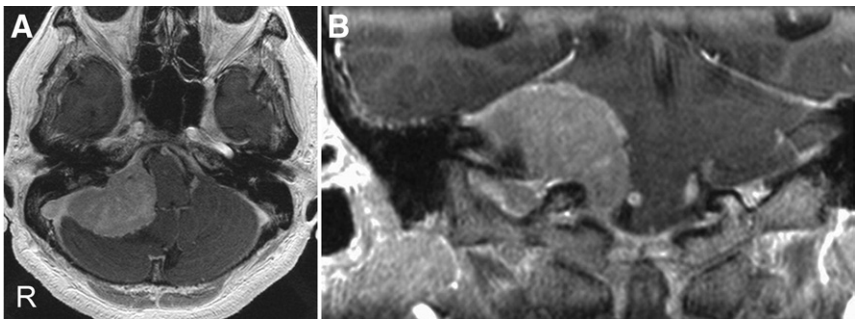

Figure 2. Axial (**A**) and coronal (**B**) views of magnetic resonance imaging (MRI) for posterior petrous type showed meningioma at the right cerebellopontine angle (CPA) attached to the posterior petrosal dura. The attachment was confirmed intraoperatively.