Developmental Patterns and Characteristic Symptoms of Petroclival Meningiomas

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Abstract

Thirty-six cases of petroclival meningiomas with clearly defined anatomical features were selected to analyze the site of tumor attachment and the displacement of the trigeminal nerve. The tumors were classified into four categories according to the origin and extension of the tumor: clival origin medial to the trigeminal nerve (upper clivus type), clival origin with dumbbell extension to the cavernous sinus (cavernous sinus type), tentorial origin over the trigeminal nerve (tentorium type), and petrous apex origin lateral to the trigeminal nerve (petrous apex type). Patients with tumors in each category had characteristic neurological symptoms. Patients with the upper clivus type had oculomotor nerve paresis as a single symptom, if suprasellar tumor extension was present. Patients with the cavernous sinus type commonly presented with abducens nerve paresis caused by epidural tumor invasion around Dorello's canal. Dumbbell tumor extension along the venous drainage of the cavernous sinus was a significant problem for surgical removal in this type. Half of the patients with the tentorium type had a characteristic symptom of trigeminal neuralgia caused by retrograde tumor invasion from Meckel's cave from its orifice, but the cavernous sinus was not involved. The main complaint of patients with the petrous apex type was hearing disturbance, but no epidural or parasellar extension was present. Clinical symptoms and magnetic resonance imaging provide important information about the origin and extension patterns of these tumors, especially the presence or absence of tumor extension into the cavernous sinus. Abducens nerve paresis or trigeminal neuralgia suggests tumor invasion into the cavernous sinus or Meckel's cave, respectively.

Key words: petroclival meningioma, cavernous sinus, clinical symptom, surgical method

Introduction

Basal posterior fossa meningiomas can be classified into clival, petroclival, sphenopetroclival, foramen magnum, and cerebellopontine angle (CPA) types, depending on the zone of adherence. The petroclival meningioma can be broadly defined as tumors attached to the lateral sites along the petroclival borderline where sphenoid, petrous, and occipital bones meet, because large tumors commonly have wide areas of attachment. Therefore, the term petroclival meningioma has been widely applied to all posterior fossa meningiomas covering the corner of the petroclival junction. A more specific definition is a tumor originating at the petrous tip medial to the trigeminal nerve, which provides a distinction from the CPA meningiomas. Petroclival tumors are located in an anatomically complicated area containing dural folds, venous sinuses, and the third through sixth cranial nerves, so a small anatomical variation in origin will present with different clinical features and surgical indications, and have an influential factor on the outcome. This study classified carefully selected tumors with distinct origins by magnetic resonance (MR) imaging and surgical observation, to identify the characteristic clinical and anatomical differences.

Materials and Methods

This study included 36 patients with petroclival meningiomas which had anatomically distinct attachment and extension. Giant tumors with broad attachment in multiple areas or tumors without extension into the petroclival junction (medial to the trigeminal nerve) were excluded. The tumors were treated by the middle fossa transpetrosal-transtentorial approach or Dolenc's approach. The direction of

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the tumor extension was assessed from the displacement of the cranial nerves, mainly of the trigeminal nerve. The tumors were classified according to the location of the major tumor attachment and displacement of the trigeminal nerve, as follows (Figs. 1 and 2).

- **Upper clivus type:** Tumor attachment medial to the trigeminal nerve, with lateral shift of the nerve. No invasion into the cavernous sinus.
- **Cavernous sinus type:** Tumor attachment medial to the trigeminal nerve, with dumbbell tumor extension into the cavernous sinus and into the posterior fossa, with lateral shift of the trigeminal nerve.
- **Tentorium type:** Tumor attachment on the tentorium above the trigeminal nerve, with inferior shift of the nerve.
- **Petrous apex type:** Tumor attachment on the petrous apex, lateral to the trigeminal nerve and medial to the internal auditory canal, with superomedial shift of the trigeminal nerve.

The clinical signs and symptoms, tumor extension into the parasellar space, type of tentorial extension (Fig. 3), and surgical results were analyzed for each type.

**Results**

The results are summarized in Table 1.

Upper clivus type (5 patients): Two patients complained of oculomotor nerve paresis. The tumor extended along the dura of the oculomotor trigone,
and strongly compressed the nerve anteriorly at the dural hole. The fourth and sixth cranial nerves were displaced and partially encased in four and three patients, respectively, but were asymptomatic. Two patients had epidural tumor extension into the basilar plexus. The carotid artery was engulfed or encased in the C4–C5 portion in six patients, so clear dissection of the adhesive tumor away from the carotid artery was always risky (Fig. 4 upper right). Meckel’s cave was involved in nine patients, six of whom had facial hypesthesia. Four were considered to have the tumor origin in Meckel’s cave. The trigeminal nerve is normally separated loosely in the anterior part of the cave, allowing tumor removal. However, the tumor was difficult to separate when intermingled in the trigeminal nerve fibers, which were sacrificed partially or totally in such cases. Seven of the patients presented with tumor extension to both surfaces of the tentorium (Fig. 3 center). Three of them also had tumor extension between the two layers of the tentorium (Fig. 3 right), with erosion of the petrous pyramid. Seven tumors were removed totally. Tumor regrowth was seen in three of four tumors with incomplete removal.

Tentorium type (10 patients): Seven patients had trigeminal nerve symptoms, of whom five complained of trigeminal neuralgia, which was a characteristic symptom of this type. A compressed, fan-like extended trigeminal nerve was observed at the entry zone in those patients. Six patients including those with trigeminal neuralgia showed retrograde tumor extension into Meckel’s cave through its orifice (Fig. 4 lower left). However, the tumor merely encased the trigeminal nerve tightly and could be dissected from the trigeminal nerve root by the opening of Meckel’s cave. The trochlear nerve was encased at the point of dural penetration in all patients, but only one complained of double vision. The tentorium was invaded and strongly compressed the nerve anteriorly at the dural hole. The fourth and sixth cranial nerves were displaced and partially encased in four and three patients, respectively, but were asymptomatic.

Cavernous sinus type (11 patients): Nine patients complained of double vision, of whom eight presented with unilateral abducens nerve paresis and two with oculomotor nerve paresis (one patient had multiple extraocular pareses). All patients had a tumor in the inferomedial triangle of the cavernous sinus, along with the epidural course of the abducens nerve passing through Dorello’s canal. The carotid artery was engulfed or encased in the C4–C5 portion in six patients, so clear dissection of the adhesive tumor away from the carotid artery was always risky (Fig. 4 upper right). Meckel’s cave was involved in nine patients, six of whom had facial hypesthesia. Four were considered to have the tumor origin in Meckel’s cave. The trigeminal nerve is normally separated loosely in the anterior part of the cave, allowing tumor removal. However, the tumor was difficult to separate when intermingled in the trigeminal nerve fibers, which were sacrificed partially or totally in such cases. Seven of the patients presented with tumor extension to both surfaces of the tentorium (Fig. 3 center). Three of them also had tumor extension between the two layers of the tentorium (Fig. 3 right), with erosion of the petrous pyramid. Seven tumors were removed totally. Tumor regrowth was seen in three of four tumors with incomplete removal.

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on both sides in two patients, but there was no tumor invasion into the cavernous sinus. Nine of the 10 tumors were excised totally.

Petrosal apex type (10 patients): Nine of these patients had unilateral hearing disturbance, and five presented with associated facial hypesthesia. Eight patients had tumor extension on the tentorium, but only one showed tentorial encasement. None had epidural tumor extension. One patient had tumor invasion into the internal auditory canal (Fig. 4 lower right), and the surgical technique was focused on preservation of the facial nerve. Eight of the 10 tumors were excised totally.

**Discussion**

The clinical signs of petroclival meningiomas are third to eighth cranial nerve deficits and cerebellar signs, and the common symptoms are ataxia, facial hypesthesia, diplopia, and hearing disturbance. However, the incidence of each symptom varies with the most common cranial nerve symptoms being facial hypesthesia or pain (45–67%) and hearing disturbance (50–75%). The incidence of extraocular paresis was lower and varied widely from 0–41%, which may be caused by the differences in tumor origin and extension. The incidence of extraocular paresis was up to 50% in patients with limited tumors originating at or medial to the trigeminal nerve, and
more than 50% in patients with tumors extending into the parasellar space (sphenopetrosal meningiomas). Presumably the patients who presented with a high incidence of hearing disturbance included many tumors originating from the CPA, and the patients with a high incidence of extraocular paresis included more tumors originating from the clivus or the cavernous sinus.

In this study, patients were mostly asymptomatic even if the trochlear or abducens nerve was displaced or encased subdurally by the tumor as in the upper clivus or tentorium type. Extraocular nerve deficits are unusual despite their frequent and intimate involvement in the subdural tumor. However, patients complained of double vision (abducens nerve paresis) once the tumor extended into the posterior cavernous sinus as in the cavernous sinus type. This type of tumor could be considered as gasseropetrosal tumor3) or sphenopetrosal meningioma21) in the original classification. The abducens nerve runs epidurally in the inferomedial triangle of the cavernous sinus from the point of dural penetration to Dorello's canal. This portion of the abducens nerve is protected by the dura, but is vulnerable once the tumor invades the epidural space because the nerve is fixed by hard structures, such as dura, bone, and petroclinoid ligament (Gruber's ligament). The cavernous sinus type may originate from the meningeal wall of Meckel's cave or of the posterior cavernous sinus, and invade the abducens nerve epidurally in the early stage of tumor extension. In contrast, the subdural part of the trochlear and abducens nerves may be resistant to tumor invasion until the late stage, because of the mobility of these nerves in the subarachnoid space. Therefore, abducens nerve paresis occurring in the early tumor stage is a sign of tumor extension into the posterior cavernous sinus. Meningiomas originating from the cavernous sinus fairly commonly extend into the petroclival area at regrowth. Such tumors are sometimes associated with erosion of the apical petrous bone, and with tumor extension along the venous drainage of the cavernous sinus (Fig. 5). The preoperative diagnosis must focus on whether the tumor extends into these areas, because complete resection is difficult to achieve by the suboccipital or transcochlear approach. Complete resection can only be achieved by surgical approaches allowing opening of the posterior cavernous sinus, but may also depend on tumor adherence to the carotid artery and to the brainstem. Postoperative radiosurgery may be indicated in patients undergoing incomplete removal.

In contrast, the parasellar component of the tentorium type tumors consisted not of cavernous sinus invasion but retrograde tumor invasion into Meckel's cave. Such invasion is usually not found before surgery by computed tomography because of bone artifacts. Detailed MR imaging study is important for this type of meningioma, because Meckel's cave is located more inferolaterally than the cavernous sinus. This type of tumor might be classified as gasseropetrosal tumor as well, but should really be in a different category because of the tumor origin on the tentorium over the orifice of Meckel's cave and the tendency towards less invasion of the cavernous sinus. The thick anterior and posterior dural folds of the plica petroclinoid may prevent epidural tumor invasion. The petrolingual ligament and the medial thick wall of Meckel's cave may contribute to protect the lower cavernous sinus. The tumor could be resected in one stage surgery by the middle fossa anterior transpetrosal approach, even with parasellar extension. Trigeminal neuralgia, a characteristic symptom in such patients, could be relieved by tumor removal. Preservation of the trochlear nerve is essential to avoid ocular complications. The petrous apex type tumor is the so-called CPA tumor with attachment to the anterior petrous pyramid extending medially. Tumor extension into the middle fossa, parasellar space, or epidural space was uncommon in this type of the tumor. The surgical approach could be either the suboccipital or transpetrosal approach, focusing on functional preservation of the facial and cochlear nerves in patients with preoperative useful function, as for acoustic neuromas.

References


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