Clivus Meningioma: Six Cases of Total Removal

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Summary

Meningiomas which arise from the clivus are extremely rare. According to Dany\(^8\), the incidence of this tumor is 8.4\% of the meningiomas of the posterior fossa and 0.125\% of all brain tumors. The clinical features of the clivus meningioma consist of asymmetrical bilateral cranial nerve involvements (especially V, VII, VIII, IX, X), cerebellar and long tract signs and increased intracranial pressure. Practically, VAG and CAG are the most useful diagnostic procedures.

Results of treatment have been quite disappointing, primarily because of the position of the mass which is anterior to the brain stem and in direct contact with the vertebral and/or basilar artery. Most neurosurgeons would consider it to be inoperable and would simply perform a biopsy or partial removal. However, when the tumor is not too large and hard, total removal of a clivus meningioma should be tried with some precautions. The approach must be chosen to provide the shortest access to the main feeders, and multisided exposure should be obtained according to the location and the extension of the tumor. The results which have been obtained in our own 6 cases are encouraging.

Key words: meningioma, clivus, total removal

Case Reports

Case 1. A 45-year-old male presented a 2-year history of difficulty in walking and swallowing, a one-year history of double vision on looking to his left, leaking of saliva and food from the left corner of the mouth, and a few months history of psychic disturbances such as easy crying and forced laughter.

Examination showed left abducens palsy, absent corneal and gag reflex on the left side, left peripheral facial paresis, dysarthria, positive Romberg's sign, horizontal nystagmus on the left lateral gaze, and limb ataxia on the left side. Plain roentgenograms were negative. Bilateral retrograde vertebral angiogram (VAG) demonstrated that the basilar tip was displaced 2 cm backward (Fig. 1A) and shifted to the right (Fig. 1B). The left posterior cerebral artery was displaced upward and arched. The left superior cerebellar artery was shifted backward and medially (Fig. 1B). Left carotid angiogram (CAG) showed that the carotid siphon was opened. There were several tumor vessels coming from meningeal branches off the cavernous portion of the left internal carotid artery (Fig. 2). Pneumoencephalograms demonstrated no air in the ventricular system and bilateral pontocerebellar cisterns. The pericallosal cistern was widened.

Operation. On Sep. 25, 1972, left temporo-occipital craniotomy and left suboccipital craniectomy as well as left mastoidectomy and removal of the posterior part of the petrosal bone were performed. The left sigmoid sinus was divided. Amputation of the lateral half of the cerebellar hemisphere and tentoriotomy were made. A round granular, hard-elastic, and unsuckable mass was located ventral to the brain stem and attached to the left upper lateral part

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of the clivus, and very stretched 5th, 7th and 8th cranial nerves ran over the dorso-lateral surface of the tumor. While removing the last portion of the tumor adherent to the basilar tip, profuse bleeding from the proximal portion of the posterior cerebral artery was encountered. It was controlled by application of Weck's clips.

**Histological Diagnosis.** Meningotheliomatous meningioma.

**Postoperative Course.** The patient was semicomatose, took a downhill course and expired 2 days after the surgery.

**Case 2.** A 27-year-old female presented a one-year history of intermittent bifrontal headache and double vision, and a four-month history of tinnitus on the left side. Gradual loss of hearing, tinnitus and progressive weakness of the facial muscle appeared on the left side and intermittent nausea was seen over the last few months. Two weeks prior to admission, she noted decreasing visual acuity on the left side and difficulty in walking.

Examination showed papilledema of 2 diopters, coarse nystagmus on the left lateral gaze and bilateral limb ataxia which was severer on the left side. Absent corneal reflex, abducens palsy, moderate degree of peripheral facial palsy, hearing impairment and diminution of gag reflex were noted on the left side, and inclination of the uvula to the right and deviation of the tongue to the left were observed. Caloric test showed no response on the left side. Left CAG showed findings of moderate degree of ventricular dilatation and several tumor feed-
ers coming from meningeal branches of the cavernous portion of the left internal carotid artery. On July 23, 1973, a V-P shunt was performed. Bilateral VAG revealed that the basilar artery was displaced 2 cm backward (Fig. 3A) and shifted to the right (Fig. 3B).

Fig. 3 Case 2. A: Vertebral arteriogram, lateral view (retouched). The basilar artery is displaced 2 cm from the clivus. B: A-P view (retouched). The left vertebral and basilar arteries are shifted to the right. The left AICA is elevated and stretched (arrow).

Operation. On Aug. 15, 1973, with the patient in the sitting position, the posterior fossa was explored through a left suboccipital craniectomy and mastoidectomy. The entire length of the sigmoid sinus was exposed and retracted anterolaterally. A large hard mass was found to be present anterior to the brain stem, extending into the left C-P angle and attached to the dura at the region of the spheno-occipital synchondrosis. It extended up to the posterior clinoid process of the dorsum sellae and down to the C1 lamina. The left fifth to eleventh cranial nerves were elevated and tightly stretched by the mass. A deep depression in the pons and medulla as well as the biventral cerebellar lobules was noted. The medulla was pushed and rotated to the right. The left vertebral artery lay between the mass and the ventral surface of the medulla. The left posterior inferior cerebellar artery (PICA) which penetrated the tumor had to be sacrificed. All the tumor was removed piece meal with tedious dissection requiring thirteen hours. All the cranial nerves were preserved.

Histological Diagnosis. Meningotheliomatous meningioma.

Postoperative Course. The postoperative course was stormy and tracheostomy was performed. She showed left facial paresis, left deafness and difficulty in swallowing, but her condition gradually improved. VAG showed that the basilar artery had returned to normal position (Fig. 4). At the 6th month after the operation she was able to do her house work very well. On follow-up 3 years later, she showed only moderate facial paresis and analgesia in the...
area innervated by the first and second branches of the trigeminal nerve on the left side.

**Case 3.** A 33-year-old female presented a 6-year history of headache and occasional double vision, a 4-year history of staggering gait, and frequent nausea and emesis of 2 months duration.

Examination showed left abducens palsy, anisocoria (right: 3 mm, left: 2 mm), positive Romberg's sign, absent bilateral superficial abdominal reflex, and ataxic gait. Brain scan with radioisotopes showed a large uptake posterior to the clivus. Left CAG showed the findings of a huge mass on the clivus, extending up to the tuberculum sellae and down to the foramen magnum, fed by large meningeal branches arising from the cavernous portion of the internal carotid artery (Fig. 5). Bilateral VAG showed that the basilar tip was displaced 2 cm backward from the clivus and small feeders coming from meningeal branches off the cavernous portion of the right internal carotid artery (Fig. 6A). The peduncular segments of the left posterior cerebral artery and superior cerebellar artery were displaced posteromedially and arching around the mass. The basilar artery was bowed and shifted to the right about 2 cm from midline. The proximal segment of the left anterior inferior cerebellar artery (AICA) was displaced infero-medially and its distal segment was shifted backward and markedly stretched (Fig. 6B).

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First Operation. On July 9, 1975, a left fronto-temporo-occipital craniotomy combined with a left suboccipital craniectomy was carried out. The tentorium was divided. Then through a subfrontal approach combined with a sub-
temporal one, the anterior pole of the tumor was exposed. The tumor was extremely hard and obviously a meningioma. It was extending up to the tuberculum sellae and the left optic nerve was markedly compressed and elevated. First, the lateral part of the tumor was attacked and the main feeders from the meningeal branches were coagulated and divided, and the upper one third of the tumor was removed. And then through a subtemporal transtentorial approach the tumor extending into the cerebello-pontine angle was partially removed. Postoperatively, there was no neurological deficit except for slight and transient left oculomotor paresis.

**Second Operation.** Two weeks later, with the patient in the sitting position, the left suboccipital craniectomy wound was reopened and additional removal of the medial part of the occipital bone with a laminectomy of C1 was made. The lateral half of the left cerebellar hemisphere was amputated. The remaining tumor was located anterior to the brain stem and extending into the left cerebello-pontine angle. The left trochlear, trigeminal and abducens nerves were running over the tumor and had to be sacrificed at the time of removal of the tumor. The left facial and acoustic nerves ran on the dorso-inferior surface of the tumor, accompanied by a dilated AICA. These cranial nerves could be preserved, but the AICA which penetrated the infero-medial wall of the tumor had to be coagulated and divided in order to remove the tumor totally. The tumor had produced a very deep depression in the pons, medulla and left cerebellar hemisphere.

**Histological Diagnosis.** Angioblastic meningioma.

**Postoperative Course.** The patient was more ill and obtunded after the second operation, showing left oculomotor, abducens and facial palsy, spastic paralysis of four limbs and difficulty in swallowing. Tracheostomy was made. One month after the operation, she became alert but could not speak and feeding gastrostomy was made because of trismus and poor movement of the tongue. She could move her left limbs fairly well, but right hemiplegia was still present. Ten months after the operation, she was still improving. She had left abducens palsy, but her trismus was becoming less severe and movement of the tongue was good. She could swallow and no longer required gastrostomy and tracheostomy. She could speak well, although she had hoarseness due to paralysis of the left vocal cord. Although she showed moderate paresis of the right upper limb and had to use a wheelchair because of truncal ataxia, she could take care of herself.

**Case 4.** A 54-year-old, right-handed female presented a 5-year history of tinnitus and impaired hearing in the right ear, clumsiness of the feet of several months duration associated with dysarthria, and occasional frontal headache, and impaired left visual acuity present over the last three weeks. The positive findings on examination were anisocoria (left: 6 mm, right: 3 mm), Parinaud’s sign, left ptosis, left hearing impairment, deviation of the protruded tongue to the right, slight right hemiparesis and moderate ataxic gait. Skull and chest roentgenograms were normal. Brain scan with radioisotopes showed slightly increased uptake in the left half of the base. Left CAG showed abnormal vascular shadow fed by meningeal branches arising from the cavernous portion of the left internal carotid artery. Bilateral retrograde VAG revealed that the upper one third of the basilar artery was displaced 1 cm posteriorly (Fig. 7A) and to the right and the left posterior cerebral artery was elevated and arched. The left superior cerebellar artery was displaced medially (Fig. 7B).

**Operation.** On Nov. 7, 1975, V-P shunt was performed. On Nov. 10, 1975, the patient was placed in the semisitting position, with the head turned toward the side of the lesion and maximally flexed, and a left transpetrosal-transtentorial approach combined with a left suboccipital craniectomy was performed. The tentorial edge was markedly elevated by the tumor underneath it. After the arachnoid covering of the tumor had been completely divided, the surface of the tumor was coagulated and gutted out with sucker, coagulator and scissors. Then dissection was directed to the attachment of the tumor at the superior lateral surface of the clivus and the tumor feeders coming from meningeal branches off the cavernous portion of the left internal carotid artery were coagulated and divided. The midbrain was considerably elevated and rotated to the right by the tumor. It was necessary to enter the interpeduncular fossa and by doing so the tumor came out suprisingly
simply. The two tumor branches from the peduncular segment of the posterior cerebral artery were clipped and divided. The left oculomotor nerve ran around the superior dorsal surface of the tumor and was adherent to it. This elongated and thin left 3rd cranial nerve was carefully preserved. The 5th, 7th and 8th cranial nerves which were running on the dorso-inferior surface of the tumor were easily separated from it. Finally, total removal of the tumor was completed.

Histological Diagnosis. Meningotheliomatous meningioma.

Postoperative Course. The patient's postoperative course was quite uneventful. VAG showed that the basilar artery and its tributaries had returned to almost normal position (Fig. 8). Her neurological conditions including left hearing were markedly improved. She was discharged 1 month after the surgery with some neurological deficits such as mild left oculomotor paresis and clumsy tandem gait. At the 4th month after the operation, she returned to her original job as a flower arrangement teacher. Her oculomotor paresis was almost completely undetectable. She could walk very well.

Fig. 7 Case 4. A: Vertebral arteriogram, lateral view (retouched). The basilar artery is displaced more than 1 cm posteriorly from the clivus. B: A-P view (retouched). The basilar artery is shifted 1 cm to the right and stretched and the left posterior cerebral artery is arched. The peduncular segments of the left posterior cerebral artery are elevated and arched and that of the superior cerebellar artery is displaced medially and backward. The proximal segment of the left AICA (arrow) is slightly displaced downward and stretched.

Fig. 8 Case 4. Postoperative vertebral arteriogram, A-P view (retouched). The basilar artery and its tributaries have returned to almost normal position.

Case 5. A 33-year-old female presented a brief episode of double vision about 8 years ago, a two-year history of blurred vision, intermittent occipital headache, impaired right hearing acuity and temporal visual field defect of the left eye, a 10-month history of progressive numbness of the left side of her face, and poor
equilibrium, periodic vertigo, severe occipital headache, finger tremors and right tinnitus of few months duration. Examination showed optic atrophy more on the right, temporal visual field defect of her left eye, hypalgesia in the left half of the face, bilateral abducens palsy, decreased hearing acuity on the right, diminution of bilateral gag reflex, slight left hemiparesis and ataxic gait. Visual acuity was 0.2 on the right and 0.01 on the left. The spinal fluid protein was 150 mg/dl. Plain skull X-ray was normal. Brain scan with radioisotopes showed moderately increased uptake in the retroclival portion. Bilateral VAG demonstrated posterior displacement of the right vertebral and basilar arteries and tumor vascularity in the right cerebellopontine angle fed by the right PICA which was also displaced posteriorly (Fig. 9A, 9B).

Operation. On January 13, 1976, with the patient in the sitting position, a suboccipital craniectomy was performed. A large hard mass was found to be located anterior to the brain stem and attached to the right side of the lower two thirds of the clivus. The proximal segment of the right PICA which penetrated the inferodorsal part of the tumor had to be divided at its origin from the vertebral artery at the time of removal of the last piece of the tumor. The distal stump of the right PICA was anastomosed with the right occipital artery. After about 95% of the tumor had been removed, the remaining mass at the medial part of the right jugular notch was cauterized.

Histological Diagnosis. Fibroblastic and meningotheliomatous meningioma.

Postoperative Course. The patient awakened promptly after the surgery, but she had considerable difficulty in speaking and swallowing. She showed cerebellar signs which were more pronounced on the right and poor motor function of the right 5th, 7th and bilateral 10th cranial nerves. Function of the other cranial nerves was unchanged. She improved slowly. On discharge, main disabilities were extreme unsteadiness and inability to walk without assistance. The right facial weakness was improved moderately and she could swallow well, but she could not phonate due to tonic closure of the vocal cords for which continuous tracheostomy was necessitated.

Case 6. A 53-year-old female presented a 4-year history of double vision progressive left hearing disturbance, incoordination of the left leg and left facial palsy, and a two-month history of hoarseness, headache and intermittent bilateral tinnitus. The positive findings on examination were hypalgesia on the left half of the face, left abducens palsy, left peripheral facial weakness, left deafness, hoarseness, atrophy of the left half of the tongue, and bilateral ataxia,
more pronounced on the left and worse in the legs than in the arms. Skull and chest roentgenograms were normal. Brain scan with radioisotopes showed remarkably increased uptake in the left cerebello-pontine angle. Left CAG showed several tumor vessels arising from meningeal branches off the internal carotid artery and from the ascending pharyngeal artery (Fig. 10). Bilateral VAG revealed that the left AICA was elevated and stretched markedly and the proximal segment of the left superior cerebellar artery displaced medially (Fig. 11).

Operation. On Feb. 16, 1976, a transpetrosal-transtentorial approach combined with a suboccipital craniectomy was performed. A large lobular mass arising from the lower two thirds of the clivus extended into the left cerebello-pontine angle. Twenty-five grams of tumor tissue were removed and the remaining tumor at the medial edge of the jugular foramen was cauterized. The left 9th, 10th, 11th cranial nerves, which were running on the dorso-inferior surface of the tumor and enveloped by the tumor near the jugular foramen, had to be sacrificed at the time of the surgery.

Histological Diagnosis. Meningotheliomatous and fibroblastic meningioma.

Postoperative Course. Although the patient awakened promptly after the surgery, she had considerable difficulty in speaking and swallowing, necessitating tracheostomy and gastrostomy. The left facial paresis was worsened and the left glossopharyngeal, vagal and accessory nerves were completely paralyzed. Functions of other cranial nerves were unchanged. At 11 months after surgery, she was still improving. She could swallow and no longer required gastrostomy and tracheostomy. She became able to care for herself. She walked without assistance, although still clumsy. The left facial palsy was improved.

The summary of our six cases is shown in Table 1.

Discussion

Castellano and Ruggiero defined the clivus meningioma as a tumor that arises from the clivus dura excluding the anterior rim of the foramen magnum. We found only 44 cases including our 6 patients in which the description of the site of dural attachment satisfied this definition. In our 6 cases the sites of dural attachment of the tumor to the clivus were verified upon total

Fig. 10 Case 6. Left carotid arteriogram (retouched), lateral view. Several tumor vessels coming from meningeal branches off the internal carotid artery (large arrow) and from the ascending pharyngeal artery (small three arrows) are noted.

Fig. 11 Case 6. Vertebral arteriogram (retouched), A-P view. The proximal segment of the basilar artery is shifted to the right, the left AICA is markedly elevated and stretched (arrow) and the proximal segments of the left superior cerebellar and posterior cerebral arteries are medially and superiorly displaced.
Table 1  Summary of our 6 cases of clivus meningioma

<table>
<thead>
<tr>
<th>No. of case</th>
<th>Sex/Age</th>
<th>Initial symptoms</th>
<th>Neurological findings on admission</th>
<th>Duration (yrs.)</th>
<th>Dural attachment of the tumor</th>
<th>Type of therapy</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M 45</td>
<td>gait and swallowing disturbances</td>
<td>psychic disturbance (easy crying and forced laughter), V, VI, VII, IX and Xth cranial nerve involvements, horizontal mystagmus, and limb ataxia</td>
<td>2</td>
<td>upper clivus</td>
<td>total removal</td>
<td>died 2 days after surgery</td>
</tr>
<tr>
<td>2</td>
<td>F 27</td>
<td>headache and double vision</td>
<td>papilledema, V, VI, VII, VIII, IX, X and VIIth cranial nerve involvements, horizontal mystagmus, and limb ataxia</td>
<td>1</td>
<td>middle clivus</td>
<td>total removal</td>
<td>excellent 3 years after surgery</td>
</tr>
<tr>
<td>3</td>
<td>F 33</td>
<td>headache and double vision</td>
<td>III and VIth cranial nerve involvements, and ataxic gait</td>
<td>6</td>
<td>upper clivus</td>
<td>total removal</td>
<td>moderately impaired; unable to walk due to ataxia 1 1/2 years after surgery</td>
</tr>
<tr>
<td>4</td>
<td>F 54</td>
<td>right tinnitus and impaired right hearing double vision</td>
<td>III, VIII and XIth cranial nerve involvements, right hemiparesis, and ataxic gait</td>
<td>4</td>
<td>upper clivus</td>
<td>total removal</td>
<td>excellent 1 year after surgery</td>
</tr>
<tr>
<td>5</td>
<td>F 33</td>
<td>headache and impaired left hearing double vision</td>
<td>optic atrophy (bilateral), temporal visual field defect of left eye, V, VI, VIII, IX and Xth cranial nerve involvements, and left hemiparesis</td>
<td>2</td>
<td>lower clivus</td>
<td>total removal</td>
<td>markedly impaired; severe ataxia and tonic closure of vocal cord 1 year after surgery</td>
</tr>
<tr>
<td>6</td>
<td>F 53</td>
<td>double vision, incoordination of left leg and left facial palsy</td>
<td>V, VI, VII, VIII, X and XIIth cranial nerve involvements, and severe ataxia</td>
<td>4</td>
<td>middle to lower clivus removal</td>
<td>total removal</td>
<td>fairly good; able to walk with moderate ataxia 1 year after surgery</td>
</tr>
</tbody>
</table>
removal. In all the cases except for Case 6, it was observed that the site of attachment consisted only of a small circular portion of the dura with a diameter of 1–1.5 cm under which the bone was eroded. In Case 6, the dural attachment was wide (Fig. 12).

Symptoms and signs of these 44 cases which form the basis of the present study are summarized in Table 2. Incidences appear more in females; female 29 and male 15. The age range is from 5 months to 66 years with the average 43.2 years. The duration of symptoms from onset to first hospitalization averages 3.2 years with a range of 1 month to 17 years. Carefully reviewing published reports, the order of appearance of neurological symptoms and signs is so various and incoherent that early diagnosis is very difficult and has practically never been achieved. The symptoms and signs of clivus meningioma may be grouped under the following headings.

1) Symptoms and signs due to cranial nerve involvements. These are diagnostic for localization of the tumor. Regarding frequency of the cranial nerve involvements, the fifth and eighth are followed by the sixth and seventh, the ninth and tenth, and the third, in that order. The fifth nerve involvement ipsilateral to the tumor is found in about 70% of the cases and hearing loss on the side of the tumor is noted with the same frequency. Facial and abducens palsy ipsilateral to the tumor are noted in about 60% and 40%, respectively. Nearly 30% of the patients have dysphagia and absence of gag reflex or poor movement of the soft palate and uvula on phonation, and oculomotor palsy is noted with the same frequency.

2) Cerebellar symptoms and signs. These are characterized by limb ataxia or dysequilibrium and observed in about 70% of the cases.

3) Symptoms and signs due to involvement of long tracts. They are caused by brain stem compression and the pyramidal tract sign is

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### Table 2 Symptoms and signs associated with clivus meningiomas

<table>
<thead>
<tr>
<th>Symptoms and signs</th>
<th>Number of patients</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased intracranial pressure</td>
<td>31</td>
<td>70</td>
</tr>
<tr>
<td>Cerebellar involvement</td>
<td>31</td>
<td>70</td>
</tr>
<tr>
<td>Impairment of fifth nerve</td>
<td>30</td>
<td>68</td>
</tr>
<tr>
<td>Decrease or loss of hearing</td>
<td>28</td>
<td>64</td>
</tr>
<tr>
<td>Facial palsy</td>
<td>25</td>
<td>57</td>
</tr>
<tr>
<td>Involvement of corticospinal tract</td>
<td>25</td>
<td>57</td>
</tr>
<tr>
<td>Involvement of sixth nerve</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>Involvement of ninth and tenth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nerves</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td>Involvement of third nerve</td>
<td>12</td>
<td>27</td>
</tr>
<tr>
<td>Nuchal rigidity</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>Nystagmus</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>Sensory impairment in limbs</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>Forced laughter</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
present in about 60% of the cases, and sensory impairment of the limbs in 16%.

4) Symptoms and signs due to increased intracranial pressure. Headache and papilledema are seen in 70% of the patients. Other findings are nystagmus and nuchal rigidity, and each is seen in 25% of the cases. Very rarely, a clivus meningioma may produce the syndrome of basilar artery insufficiency, and forced laughter as seen in our Case 1.

Plain skull X-rays are usually not contributory in most cases except in the occasional instances in which calcification is present in the tumor (5 cases). The diagnostic procedure, particularly vertebral angiography in stereoviews, is very useful in order to know the location of the tumor, delimit its approximate contour and make clear its detailed relationship with the vertebrobasilar trunk and its tributaries. Carotid angiography is also very important to demonstrate feeding vessels and site of dural attachment of the tumor. Clivus meningiomas can be classified arbitrarily into the following three groups according to the sites of dural attachment from which the tumors originated. In each group, characteristic angiographical findings are observed. In meningiomas arising from the upper one third of the clivus (upper clivus meningioma) the lateral view of VAG reveals posterior displacement of the upper one-third segment of the basilar artery (Fig. 1A, 6A, 7A) and its A-P view shows that the posterior cerebral artery and basilar artery are elevated and form an arch (Fig. 1B, 6B, 7B). The superior cerebellar artery also forms a similar curve running along the posterior cerebral artery, as in Case 2 (Fig. 6B), but occasionally it is displaced backward and medially, separated from the posterior cerebral artery, as in Cases 1 and 4 (Fig. 1B, 7B). The AICA is displaced downward and medially, and runs on the inferior dorsal surface of the tumor (Fig. 1A, 1B, 6A, 6B, 7B). CAG shows tumor feeders coming from meningeal branches off the cavernous portion of the internal carotid artery and the ascending pharyngeal artery. In meningiomas arising from the lower one third of the clivus (lower clivus meningioma), bilateral VAG demonstrates posterior displacement of the ipsilateral vertebral and basilar arteries as well as lateral displacement of the vessels opposite to the tumor. The PICA is seen to be displaced posteriorly, curving around the dorsal surface of the tumor (Fig. 9B). CAG shows tumor feeders arising from the meningohypophyseal trunk, ascending pharyngeal artery and/or occipital artery. Brain scan with radioisotopes is also a helpful procedure. Five out of 6 of our cases showed increased uptake of radionuclide in the retro-clival region.

In many instances, differential diagnosis of this kind of lesion from other tumors of the posterior fossa, intrinsic neoplasms of the brain stem, and atypical degenerative and inflammatory lesions of the brain stem and cerebellum may be impossible. The acoustic neurinomas may mimic clivus meningiomas as far as signs and symptoms are concerned. The following features, however, appear to be helpful for differential diagnosis of the two tumors. The first is dysphagia, which may be an early symptom and was present in 30% of patients with clivus meningiomas. On the other hand it is a late symptom and was present in only 6% of acoustic neurinomas according to Pool.21) The second feature is the presence of pyramidal tract involvement, which was noted in 60% of clivus meningiomas, but in only 10% of acoustic neurinomas. Another feature that may be helpful is roentgenographic views of the petrosal bone; 31.6% of Pool and Pava's21) cases of eighth nerve tumor had an enlarged auditory meatus, while it is usually normal in cases of clivus meningioma. Intracranial chordomas arising from the region of the spheno-occipital synchondrosis often show the same clinical picture as clivus meningiomas. The most striking finding in roentgenograms which is contributory to differential diagnosis is that chordomas usually produce osteolytic change of the clivus and sphenoidal bone and invade the sphenoid sinus,23-25) whereas bony destruction is rarely seen in clivus meningiomas. Brain stem gliomas may also present a problem in differential diagnosis. Generally, papilledema is seen at a relatively early stage in clivus meningiomas while it
may be noted in late stages in brain stem gliomas and is twice more common in clivus meningiomas than in intrinsic brain stem gliomas.\textsuperscript{3,12}

Removal of clivus meningiomas is extremely difficult, because of their abundant vascularity and tight adhesion to many cranial nerves which are usually found running over the tumor. The basilar artery is displaced posteriorly or entangled by the tumor, and at times one or both vertebral arteries may be involved. Usually the midbrain, pons and medulla are indented by the tumor, so that separation of the tumor capsule from these structures is most hazardous, if possible at all. The operative results obtained out of the 31 patients operated upon exclusive of our 6 cases are not encouraging. Of the 31 patients, 17 died within 26 days after surgery, 3 within 18 months after biopsy or partial removal, and 1 succumbed 50 days after total removal. Seven patients were still living following partial or subtotal excision (survival range: 2 months to 12 years). Out of 3 patients with total excision of the lower clivus meningioma, 2 were worse after the surgery and showed moderate neurological impairments, including clumsy gait. Only one patient is in excellent condition 3 months after surgery. In our series, total tumor removal was accomplished in all the cases. There were two successful cases which showed excellent postoperative states (Cases 2 and 4). These operations were performed under the following precautions.

In dealing with meningiomas, it should be obvious that, because the feeding vessels are mainly through the dural attachment, the removal of such tumors would be much more bloodless and easier if these feeders could be controlled in the early stage of the procedure. For this reason, the operative approach should be selected to provide the shortest access to these main feeding arteries. Since the brain stem already distorted does not tolerate further retraction without disastrous results, multisided exposure, which will not only give more room but also help in identifying and protecting important vascular and neural structures, is indicated.

According to the location of the dural attachment and the extension of the tumor, one of following three operative approaches can be selected and each of them has been utilized in our cases. First, a subfrontal approach combined with a subtemporal one is suitable for the upper clivus meningioma extending up to the tuberculum sellae, as in our Case 3. Removal of the squama of the temporal bone as well as partial resection of the minor sphenoid wing are needed to obtain good exposure of the floor of the temporal fossa. The bridging veins over the anterior extent of the temporal lobe are coagulated and cut in order to elevate the temporal lobe. By the use of spatulas, a line of cleavage between the medial aspect of the temporal lobe and the tumor is found, widened and maintained. The second is a transpetrodssal-transtentorial approach which is a simplified modification of the translabyrinthine-transtentorial one described by Morrison and King in 1973.\textsuperscript{15)} Meningiomas in the location of the upper (Case 4) and middle clivus (Case 6) are most readily removed by this combined approach. It allows excellent access to the upper part of the tumor and brain stem with minimum interference with the cerebellum and also provides the shortest access to the main feeding vessels coming from meningeal branches off the cavernous portion of the internal carotid artery so that bleeding from the tumor can be reduced easily by coagulating these vessels. Also in this combined approach one can preserve the middle ear and the cholestea, thus offering hope of restoring or retaining hearing even with a huge tumor as in Case 4. This operation is done with the patient in a semisitting position, with the head turned toward the side of the lesion and maximally flexed. This rotation and flexion of the head are most advantageous in exposing the cerebello-pontine angle and the ventral surface of the midbrain since it permits easier illumination of the operative field. At the time of mastoidectomy and removal of the posterior part of the petrosal bone, opening of the antrum is limited and the ear ossicles are not even touched. By resecting the bone covering the sigmoid sinus with a high speed air drill, the whole length of the sinus down to the jugular bulb is exposed. The transverse sinus is separated from the covering bone. A small posterior temporal bone flap is elevated (Fig. 13A). The middle fossa dura, the superior petrosal sinus and the posterior fossa dura are separated from the petrosal bone. While thinning the petrous bone toward the apex, the sigmoid sinus is
retracted medially and the temporal lobe superiorly by brain retractors inserted between the dura and the petrosal bone. It has proved that the facial nerve and cochlea are neither exposed nor damaged if removal of the petrosal bone is limited to within 1 cm in depth from the petrosal ridge. Dural incision is made in the middle fossa and the posterior fossa as shown in Fig. 13B.

After clipping and dividing the superior petrosal sinus, tentoriotomy to the hiatus is performed. With slight upward retraction of the temporal lobe, an excellent exposure of the upper part of the tumor and the brain stem is obtained with minimal interference with the cerebellum (Fig. 13C). When the tumor is very large and extending down to the lower clivus, the dura over the posterior fossa is opened. A lateral portion of the cerebellar hemisphere is resected. It is often necessary to take the supra- and infra-tentorial approaches alternately as the tumor is gradually reduced in size. The third is a suboccipital approach for the foramen magnum and cerebello-pontine angle exposure in middle and lower clivus meningioma such as in our Cases 2 and 6. The major blood supply to such tumors arises from the ascending pharyngeal artery and occipital artery. A unilateral wide suboccipital craniectomy is performed, extending down to the foramen magnum, and laminectomy of C₁ and C₂ is added. For complete removal of the medial part of the tumor, one has to take a more lateral approach than the route through which

Fig. 13 Transpetrosal-transtentorial approach. A: Scalp incision and bone flap. The dotted lines indicate the site of removal of the bone over the junction of the transverse sinus with the sigmoid sinus. B: The extent of the dural exposure after retromastoideal craniectomy, elevation of the temporal bone flap and completion of the posterior petrosal dissection. The thick line indicates the dural incision. C: Completion of tentoriotomy. IV, V, VII and VIII: the 4th, 5th, 7th and 8th cranial nerves.
the standard unilateral suboccipital craniectomy is made. Using a high speed air drill, the craniectomy is extended anteriorly and inferiorly into the mastoid process and the petrosal bone so that the entire length of the sigmoid sinus is exposed, while taking great care to avoid injuring the facial nerve in its canal. The sigmoid sinus is retracted antero-laterally by using dural tacking sutures. The lateral half of the cerebellar hemisphere is amputated.

In the tumor removal through the above three approaches, magnification is essential and in all our 6 cases we used the operative microscope. When the tumor capsule is dissected from the surrounding important vascular and nervous structures, cotton pledgets are inserted into the line of cleavage. The tumor is then gutted with microscissors, bipolar coagulator, rongeurs and sucker. The cranial nerves, which are elevated and stretched by the tumor, are also protected with a wet cotton pledget as the tumor is mobilized. After reducing the size of the tumor, its dural attachment can be reached and the feeding branches from the meningo-hypophyseal trunk or ascending pharyngeal artery are coagulated and covered with Oxycel* soaked with Biobond† to control the bleeding and further removal of the tumor thereby becomes easier. The feeding vessels from the superior, anterior inferior and posterior inferior cerebellar arteries will become visible as the tumor is reduced in size and must be clipped and divided. The outstanding hazard of this operation is attributable to the relationship of the tumor to the surrounding vascular structures. The basilar artery may be adherent to, or even involved in the tumor. This means that occasionally a small portion of this tumor has to be left behind.

Out of our 6 cases, excellent results were obtained in one with a middle clivus meningioma (Case 2), and another with an upper clivus meningioma (Case 4). Both patients resumed their original jobs again within 6 months after surgery. One with a middle clivus meningioma (Case 6) is moderately impaired with clumsy gait but is able to take care of herself. One patient with a huge upper clivus meningioma (Case 3) is unable to walk without assistance due to ataxia and right hemiparesis. However, she can perform general self-care, although she needs a wheelchair. One with a lower clivus meningioma (Case 5) is unable to walk without assistance because of severe ataxia and she cannot phonate due to tonic closure of the vocal cords. One with an upper clivus meningioma (Case 1) died on the second postoperative day due to midbrain infarction.

Surgical treatment of the clivus meningioma is, therefore, very hazardous especially, in the hard and markedly extending tumor. To solve this problem, early diagnosis is necessary. Clivus meningioma, if operation is performed at an early stage, can be removed successfully.

References


*Biobond: An EDH-adhesive. It is made available commercially by the Yoshitomi Pharmaceutical Company, 3-35 Hirano-machi, Higashi-ku, Osaka, Japan 541. It consists of cyanoacrylate monomer 0.07 gm, nitrile rubber 0.07 gm and tolylene isocyanate 0.01 gm.

†Oxycel: Cellulosum oxydatum is supplied by Parke, Davis & Co., Detroit, U.S.A.
22) Stevenson, L. D. and Friedman, E. D.: Tumours involving the ventral aspect of the pons and medulla including two chordomas. Brain, 59: 291–301, 1936