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Technical Note

Surgery for a Case of Three-Compartment Trigeminal Schwannoma : Technical Aspects

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Complete removal of three-compartment trigeminal schwannomas is a challenge to neurosurgeons. To expand exposure of each compartment, the combination and modification of skull base approaches are necessary. The 61-year-old woman was admitted with chronic headache. Preoperative magnetic resonance imaging showed 47 × 50 × 40 mm-sized tumor originating primarily in the middle cranial fossa extended to the posterior and the infratemporal fossa. We performed operation in five stage; 1. Zygomatic osteotomy, 2. Inferior temporal fossa plate removal and foramen ovale opening, 3. Cavernous sinus opening, 4. Tailored anterior petrosectomy, 5. Meckel's cave opening. Combination of skull base surgery should be concerned according to the patient. In this study, extradural basal extension with zygomatic osteotomy, interdural posterior extension with tailored anterior petrosectomy, and intracavernous exploration are reasonable options for remodeling three-compartment lesion into a single compartment. Tailoring of bone resection and exploring through natural pathway between meningeal layers accomplish single-stage operation for complete removal of tumors.

KEY WORDS : Multiple compartment · Trigeminal Schwannoma · Technique.

INTRODUCTION

Trigeminal schwannomas arise from the junction of the Gasserian ganglion and the trigeminal nerve root[3,4,9,12]. These may be located in the middle cranial fossa, the posterior cranial fossa, or extracranial spaces. Yoshida and Kawase[14] classified extracranial tumors extending orbital, pterygopalatine, and infratemporal fossa compartments. Tumors originating primarily in the middle cranial fossa can be extended to the posterior and the infratemporal fossa through the porus trigeminus and the foramen ovale, respectively. Tumors involving three distinct compartments result in complicated clinical manifestations and radiological findings. Magnetic resonance imaging (MRI) and three-dimensional computed tomography (CT) has allowed the more clear elucidation of the pattern of extension[11,12]. They are also helpful to design surgical strategies to approach each compartments.

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In extensive literature review, there were only six cases located in three compartments among 582 cases, from 1935 to 2008[7,9,10]. Because trigeminal schwannomas are benign, complete removal of these tumors is a challenge to neurosurgeons, and a multimodal surgical approach is necessary. Various skull base approaches provide better exposure and multiple working angles but they also have several limitation of bony structures[3]. The combination and modification of skull base approaches were undergone to expand exposure of each compartment through the infratemporal fossa plate and the petrous bone. We describe a step-by-step surgical procedure of bone dissection required to expose each compartments. We also intended to define the technical details of a modified technique, which convert a three-compartment tumor into a single-compartment tumor to afford complete removal.

CASE REPORT

Illustrative case

The 61-year-old woman was admitted with chronic headache. There was no facial numbness, hypoesthesia or difficulty in mastication. The corneal sensations were normal. No other cranial nerve associated symptoms or signs were noticed. T1-

weighted MRI with gadolinium enhancement revealed hyperintense and heterogenous tumor measuring 47 × 50 × 40 mm (Fig. 1A-C). T2-weighted images showed heterogenous figure with microcystic change and intratumoral hemorrhage. The mass extended from the left middle cranial fossa to the posterior cranial fossa through the porus trigeminus pushing the brain stem to the right. It also extended into the infratemporal fossa through the enlarged foramen ovale. It invaded cavernous sinus and the cavernous segment of internal carotid artery was displaced medially. The axial temporal bone CT showed markedly widened left foramen ovale (Fig. 1D). It also revealed bone erosion of petrous apex, lateral sphenoid wall and infratemporal fossa plate. There was no calcification.

Operative technique

We started the approach in the supine position with the patient under general anesthesia and with the head turned 60° to the contralateral side. A standard frontotemporal curvilinear incision was done which was extended along the auricle. Fascia and temporal muscle were exposed, and retracted inferiorly. The frontotemporal craniotomy with a small frontal component was done. A zygomatic osteotomy improved subtemporal exposure and minimize temporal lobe retraction (Fig. 3A). The dura mater of the middle cranial fossa was elevated from the temporal base to expose the middle meningeal artery which was cauterized and cut at foramen spinosum. The foramen ovale was widened, and the inferior temporal fossa plate was thinned (Fig. 2A). We drilled thinned infratemporal fossa plate and removed with Kerrison punch and rongeur (Fig. 2B, 3B). Then, the middle fossa and the infratemporal fossa were connected and became a single compartment (Fig. 3C).

Exposure of cavernous sinus began by dissecting cleavage plane between dura propria and the lateral wall of the cavernous sinus. Peeling the dura propria, the epineural sheath of each division of the trigeminal nerve was exposd one by one (Fig. 2C). During this phase, we did not have to remove the anterior clinoid process and there was no venous oozing from the cavernous sinus. After we elevated the temporal lobe superiorly with retractor, the tumor was protruded at the extradural space through the small tearing of the lateral wall of cavernous sinus. Intracapsular enucleation of the tumor was achieved from the middle cranial fossa to the infratemporal fossa, extradurally. Intracavernous tumor was debulked through the Parkinson's triangle after which the capsule was dissected away from the Intracavernous neurovascular structures.

With angulation of the microscope, the drilling of the eroded petrous apex continued medially to expose the posterior fossa dura, that was 'petrous apexectomy' (Fig. 2D, 3D). Taking an incision of the dura exposed the tumor at the petrous apex over the superior dural cover of the Meckel's cave without sectioning the tentorium. We cut the widened porus

Fig. 1. Preoperative T1-weighted MR images with gadolinum enhancement demonstrate large mass (about 47 × 50 × 40 mm) with lobulating contour, which reveal heterogeneously enhancing hyperintense signal. A, B and C : It is localized at the left CPA cistern, Meckel's cave, inferior temporal fossa with widened foramen ovale, extended inferiorly to the left infratemporal fossa, through the foramen ovale, and compress the pons, midbrain, 4th ventricle, and left cavernous sinus. D : Axial temporal bone CT scan shows markedly widened left foramen ovale.

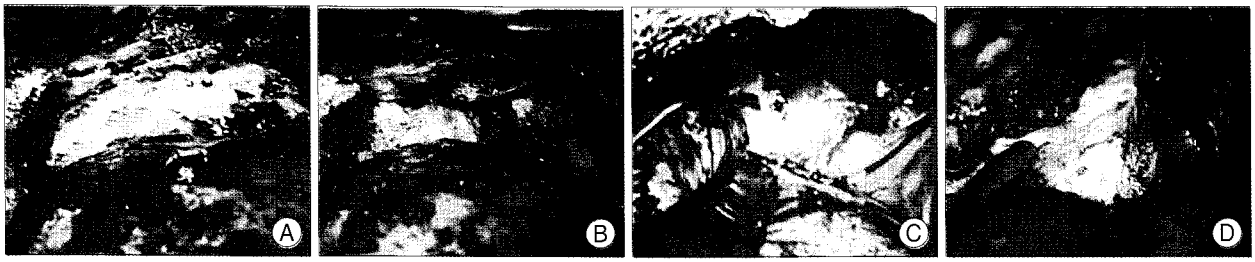

Fig. 2. Intraoperative microscopic view. A : The zygomatic osteotomy allows visualization of infratemporal fossa compartment over the thinned inferior temporal fossa plate and widened foramen ovale. B : The infratemporal fossa tumor is exposed after removal of inferior temporal fossa plate. C : The dura propria of left temporal lobe is peeling from the lateral wall of cavernous sinus. D : After petrous apexectomy, posterior fossa and porus trigeminus of the Meckel's cave are shown.

trigeminus and dural sleeve along its lateral aspect below the superior petrosal sinus. The incision was extended along the dorsolateral wall of Meckel's cave. The funnel-like mass constricted by porus trigeminus expanded. At last, another connection to the posterior fossa compartment made them a single compartment. The tumor in the lateral wall of the cavernous sinus anteiorly and the cerebellopontine angle posteriorly were exposed. We completely resected posterior fossa mass, the ventromedial brain stem restored its position and we could find intact ipsilateral anterior inferior cerebellar artery, abducens nerve, and trigeminal nerve root. We summarized these procedures on 5 stages; 1. Zygomatic osteotomy, 2. Inferior temporal fossa plate removal and foramen ovale opening, 3. Cavernous sinus opening, 4. Tailored anterior petrosectomy, and 5. Meckel's cave opening

Postoperative course

Postoperative MRI showed near total tumor removal with remaining mass at the left lateral cavernous sinus wall and widened cisternal spaces. There was small amount of intracerebral hemorrhage at surgical bed (Fig. 4). The patient presented with temporary ipsilateral trigeminal and abducens neuropathies. She had no facial pain but hypoesthesia on left face. She also suffered diplopia, however, she had full recovery in a week. Histopathologic examination was consistent with schwannoma.

DISCUSSION

Factors for selection of approaches

Surgical strategies for three-compartment tumors need combination of various approaches, since there were limitations of bony structures dividing each compartment[1,3-5,10,11]. The infratemporal fossa plate and zygomatic arch disturb access to infratemporal fossa in subtemporal approach. Goel et al.[3] reported 9 cases of infratemporal fossa interdural approach after sectioning of the zygomatic arch. The dissection of the temporalis and pterygoid muscles below the zygomatic arch make wider exposure of infratemporal fossa[13]. This approach was the shortest, perpendicular to the surface, and avoided neurovascular manipulation[3,4,13]. Transpetrosal approach should be done for tumor involving posterior fossa. Yoshida and Kawase[14] performed anterior petrosectomy and incised the lateral wall of Meckel's cave and cut the tentorium. We also drilled petrous apex but did not explore over the tentorium. In cases where the posterior mass are large, the tentorium must be cut and posterior petrosectomy may be necessary[16,17]. There were useful natural pathways connecting each compartment; the foramen ovale and the porus trigeminus, which are useful for conversion into a single compartment. If the foramen ovale is widened or thinned, it is relatively easy to access infratemporal fossa. After the tumor is extirpated from the middle cranial fossa and cavernous sinus extradu-

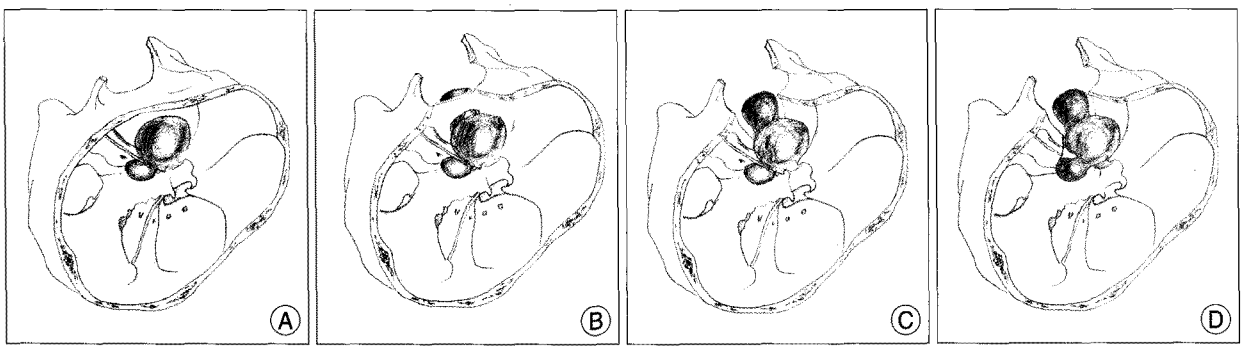

Fig. 3. Illustrations of remodeling each bony compartments. A : The zygomatic osteotomy allows extremely inferior retraction of temporalis muscle below inferior temporal fossa plate. B : Removing squamous portion of temporal bone, the infratemporal fossa tumor is partially exposed over the thinned inferior temporal fossa plate and widened foramen ovale. C : The infratemporal fossa tumor is fully exposed and is in a middle fossa compartment after removal of inferior temporal fossa plate. D : Tailoring of petrous apex permits exposure of funnel-shaped posteriorly extended tumor and release of porus trigeminus.

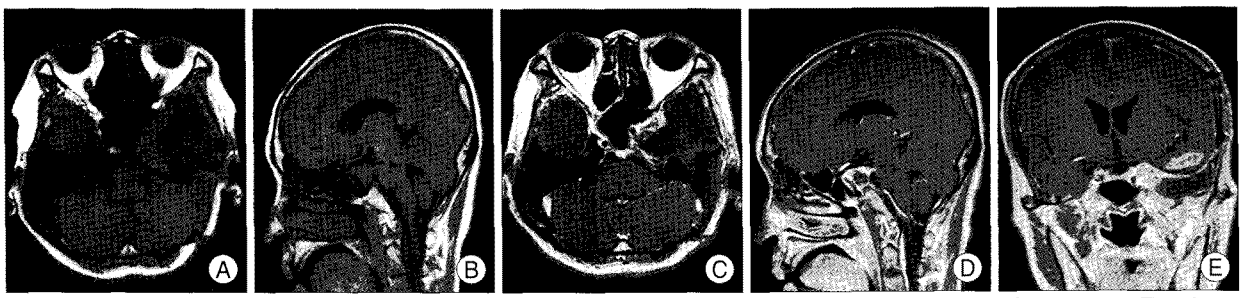

Fig. 4. Postoperative MRI shows near total tumor removal with remaining mass at left lateral cavernous sinus wall and widened cisternal spaces. There is small amount of intracerebral hemorrhage at the surgical bed. A and B : Non-contrast T1-weighted images. C, D and E : Gadolinum enhanced T1-weighted images.

rally, it can be followed into the infratemporal fossa through the foramen. Meanwhile, Al-Mefty et al.[1] also removed small dumbbell-shaped extensions into the posterior fossa through the expanded Meckel's cave (or porus trigeminus) without sectioning the tentorium or drilling the petrous apex in middle fossa approach. The extracranial tumors can be accessed via an entirely extradural approach. Jimbo et al.[5] performed transmandibular transcervical approach for parapharyngeal schwannoma, and anterolateral retromaxillary approach via gingivobuccal sulcus for pteygopalatine fossa tumors. Kouyialis et al.[7] used zygomatic and mandibular osteotomy for infratemporal fossa expansion of multicompartmental trigeminal schwannoma.

Tailored petrosectomy

The key concept to this approach is adequate bone removal of the petrous bone. The 'simple-tailoring' of petrous apex allows to expose inferiorly below the inferior petrosal sinus, and anteriorly to Meckel's cave. The extension of bone removal depends on the extension of the tumor and is limited by the otic capsule. This approach achieves an anterior direct view of brain stem and cerebellopontine angle[2,14,15]. Moreover, this approach may reduce some disadvantages, such as long operation time, high risk of facial palsy, hearing loss, and cerebrospinal fluid leakage[6]. The more posteriorly extensive transpetrosal approaches may be necessary depending on the size and extend of lesion, that is 'full-tailoring' of petrosectomy. Ramina et al.[12] suggested mastoidectomy with preservation of the labyrinth and facial nerve. The tumor was identified and completely removed in a single-stage operation. However, others thought that suboccipital approach was often adequate for tumors located mainly in the posterior fossa with small anterior extension[4].

Microsurgical anatomy for Meckel's cave manipulation

The manipulation of Meckel's cave is to dissect the complex meningeal layers. It is a dural pouch of posterior fossa dura invaginating the posteromedial portion of the middle cranial fossa. It provides a natural pathway that allows access from the middle cranial fossa[1,15]. The dural pouch of the Meckel's cave is caring an arachnoid pouch holding trigeminal nerve root. At the caudal end of the Gasserian ganglion, the arachnoid pouch is expanded conforming the dural pouch and made the trigeminal cistern[15]. The plane between the outer dural and inner epineural layer of the lateral wall of the cavernous sinus is extended over the dural pouch of the Meckel's cave and fused at porous trigeminus under the free edge of tentorium[8]. The opening of Meckel's cave is most efficient when the dura was cut from brain stem side to the periphery along the superolateral margin of the trigeminal root. The dural cut of the posterior fossa dura is extended to the porus trigeminus along the superolateral margin of the trigeminal root in the Meckel's cave.

CONCLUSION

The three-compartment trigeminal schwannomas are rare and have complicated anatomy of dural relationships and bony structures. Combination of skull base surgery should be concerned according to the patient. In this study, extradural basal extension with zygomatic osteotomy, interdural posterior extension with tailored anterior petrosectomy, and intracavernous exploration are considered reasonable options for remodeling each compartments into a single compartment. Tailoring of bone resection and exploring through natural pathway between meningeal layers accomplished single-stage operation for complete removal of tumors.

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