DOI: 10.5137/1019-5149.JTN.6430-12.0
Received: 20.04.2012 / Accepted: 07.06.2012

Case Report

Image-Guided Endoscopic Endonasal Transmaxillary Transpterygoid Approach to Meckel's Cave

Xuejian WANG, Xiaobiao ZHANG, Fan HU, Yong YU, Ye GU, Tao XIE, Junqi GE

Fudan University, Zhongshan Hospital, Department of Neurosurgery, Shanghai, China

ABSTRACT

The aim of this report was to summarize our preliminary experience on the resection of tumors located in Meckel's cave via the endoscopic endonasal transmaxillary transpterygoid approach with image-guided system and to investigate the feasibility and efficacy of this approach. Two patients who had tumors in left Meckel's cave underwent surgical treatment using the image-guided endoscopic endonasal transmaxillary transpterygoid approach. This particular technique has advantages of no brain retraction, direct vision of tumor resection and protection of surrounding neurovascular structures. Neuronavigation increases the safety of the endoscopic approach.

KEYWORDS: Meckel's cave, Endoscopic approach, Neuronavigation

INTRODUCTION

Meckel's cave (MC) is located besides the cavernous sinus. It is one of the most difficult regions in neurosurgery because of its complex anatomical structure and narrow space. The most common tumors in this region are schwannomas and meningiomas. These tumors often expand locally, compress the surrounding structures and may invade the cavernous sinus, skull base and posterior fossa. Classical approaches with craniotomy require stretching on the brain tissue, nerve and vessels. Previous microsurgical techniques with craniotomy can be roughly divided into 3 categories: anterolateral approach, lateral approach and posterolateral approach. Because of anatomical drawbacks, it is not always possible to fully expose inner side of MC and trigeminal nerve. It may be easy to leave residual tumor and it is difficult to achieve Simpson grade I resection in meningiomas (1,14,15).

In recent years, endoscopic techniques and instruments have continued to progress. Today, there are only a limited number of patients having been operated in a few specialized centers by endoscopic endonasal transmaxillary transpterygoid approach to MC (1,6,11). The indications, safety, and limits of this approach are still under investigation.

In this report, we present our experiences in 2 patients who had tumors located in the MC and who were successfully treated by pure endoscopic endonasal transmaxillary transpterygoid approach in our department. The purpose of this report was to validate the feasibility of the approach and describe several operative nuances and pearls from our experiences.

CASE REPORTS

Case 1: A 40-year-old female patient presented with numbness in the left face for less than 2 years. In her neurological examination, normal sensation in her left face, positive corneal reflex, and no muscle atrophy in masticatory muscle were observed. Brain magnetic resonance imaging (MRI) showed a mass lesion, about 4 cm in diameter, located in the left MC, slightly low and mixed signal intensity in T1, and slightly mixed signal intensity in T2 weighted images (Figure 2A-C).

Case 2: A 49-year-old male patient presented with numbness in his left face and inability to chew for four month. He was healthy otherwise, except hypertension. In his neurological examination, pinprick sensation was diminished in his left face, and corneal reflex was (-) in the left eye and (+) in the right. Brain MRI revealed a mass lesion, about 3 cm in diameter,

Corresponding author: Xiaobiao ZHANG
E-mail: 6841441@163.com.cn

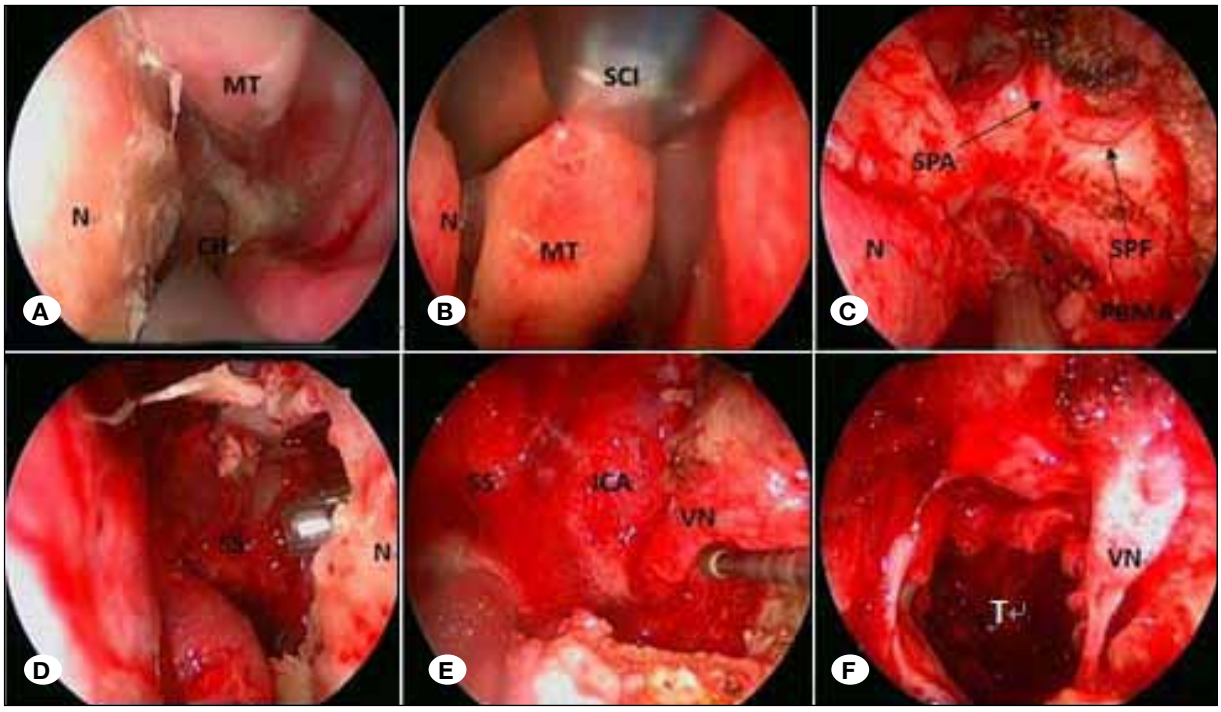

Figure 1: A) Identifying the structure of the nasal cavity; **B)** resection of the middle turbinate**; C**) management the sphenopalatine artery and the pharyngeal branches of maxillary artery, **D**) enlargement surgery for operation site, **E**) revealed vidian nerve, **F**) tumor was resected and vidian nerve was left intact. (**CH:** choana; **MT:** middle turbinate; **N:** nasal septum; **SCI:** scissors; **PBMA:** the pharyngeal branch of the maxillary artery; **SPA:** sphenopalatine artery; **SPF:** sphenopalatine foramen; **ICA:** internal cartoid artery; **SS:** sphenoid sinus cave; **T:** tumor cave; **VN:** vidian nerve).

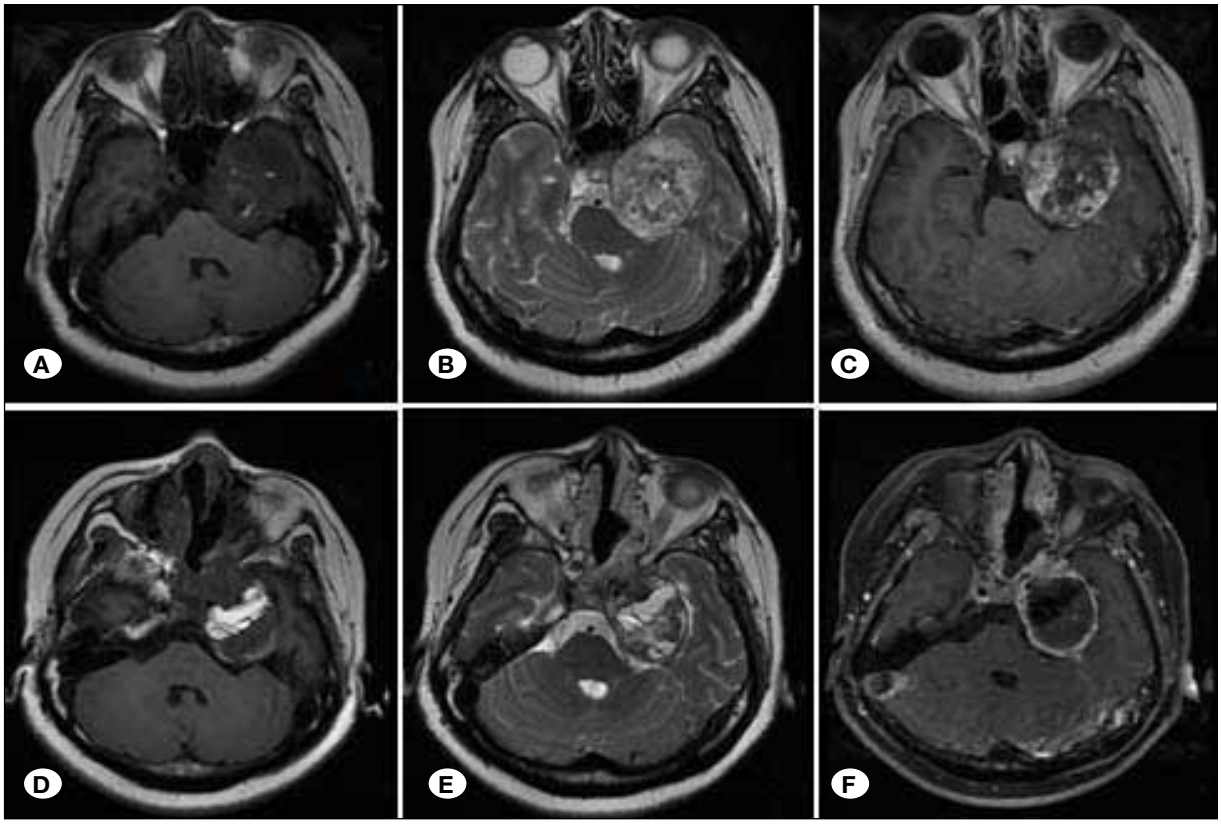

Figure 2: A-C) (axial T1, T2, and contrast-enhanced preoperative MRI, respectively) prompt left Meckel's cave tumor; **D-F)** (axial T1, T2, and contrast-enhanced postoperative MRI, respectively) tumor totally removed.

located in the left MC, low signal intensity in T1, mixed signal intensity in T2 weighted images (Figure 3 A,B).

Surgical Preparations

Both patients underwent preoperative thin-sliced computed tomography (CT) and 3-mm sliced MRI for the frameless stereotactic image guidance system in order to use during the surgical procedure. After intubation, the patient was placed and the head was fixed with Mayfield head holder. CT and MRI scans of the brain were uploaded to the frameless stereotactic guidance system (Fudan digital medical excelim-04 surgical navigation system, Shanghai, China). The navigation system was used to locate the anatomical landmarks and the tumor borders during the surgery. We used rigid-rod endoscopes 4 mm in diameter with lengths of 18 cm and lens angles of 0 and 30 degrees, mounted to a digital video camera system (Karl Storz, Tuttlingen, Germany).

Surgical Techniques

Both surgeries were performed via bi-nostril endoscopic techniques. The surgery was performed in 8 steps:

First step: The cotton sheets, which were infiltrated with saline solution mixed with 1:100,000 epinephrine and 0.5% lidocaine, were shrunk into the mucosa of bilateral nasal passages 5 minutes before the surgery.

Second step: Bilateral inferior turbinates were lateralized and the right middle turbinate was resected to enlarge the choana for a wider exposure and easy bilateral application of surgical instruments. Posterior attachment of the middle turbinate, which contains branch of the sphenopalatine artery, was coagulated by electrocautery for hemostasis. The contralateral middle turbinate was lateralized (Figure 1A-C).

Third step: A nasoseptal flap in the contralateral side was made and stored in the nasopharynx.

Forth step: The posterior nasal septum, which was the front door of bilateral sphenoidotomies and posterior ethmoidectomies, was resected.

Fifth step: The palatovaginal canal, which is located in the roof of the nasopharynx, was found and coagulated. Then, the palatovaginal canal was opened in order to reach the pterygopalatine fossa. The posterior wall of the maxillary sinus was partially removed, and the pterygopalatine fossa was opened. At this point, the vidian nerve can be seen. Image-guidance can also confirm this nerve (Figure 1D, E).

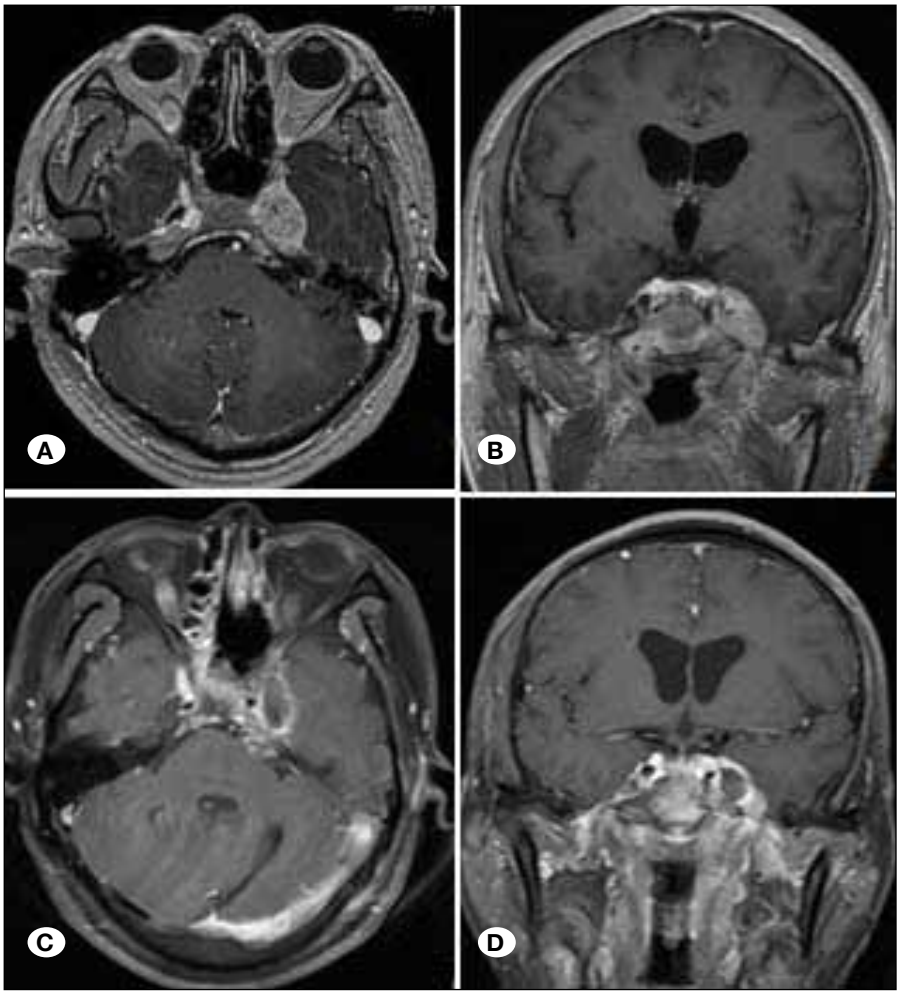

Figure 3: A, B) (enhanced preoperative axial and coronal MRI) prompt left Meckel's cave tumor; **C, D)** (enhanced postoperative axial and coronal MRI) indicates tumor subtotal removed, and part residual in left side **(D)**.

Sixth step: We drilled the floor of the sphenoid sinus to reach the same plane as the clival recess. After identification of the vidian canal by neuronavigation, we drilled its inferior and medial aspects until the exposure of whole course of the vidian nerve. Then, we transposed the vidian nerve and drilled the bone carefully around it. At last, the anterior genu of the internal carotid artery was identified.

Seventh step: We identified the V1, V2, V3, and margins of the internal carotid artery. Then, we opened this area to reach the MC and to resect the tumor.

Eighth step: After tumor resection, the tumor cavity was filled with the gelatin sponge, covered by pedicled mucosal flap, and fixed by biological glue. Bilateral nasal cavities were packed with sponges (Figure 1F).

Surgical Outcomes

The tumors were resected through endoscopic endonasal transmaxillary transpterygoid approach. Anatomical structures were clearly observed during the operation. The vidian nerve was used as a landmark for the internal carotid artery and was protected. In case 1, a total resection was achieved according postoperative MRI scans and pathological evaluation confirmed the diagnosis of schwannoma (Figure 2D-F). In case 2, a subtotal resection was performed and the histopathological examination confirmed the diagnosis of squamous cell carcinoma, which was the metastasis from nasopharyngeal carcinoma (Figure 3C, D). The patients received radiotherapy after surgery. These 2 cases were followed up for 2-6 months and no complications of dry eyes or nerve damage were observed.

■ DISCUSSION

Meckel 's cave was first defined as an anatomical structure by Meckel [1781-1833] in 1832 (13). Smith et al. reported the first surgery of trigeminal ganglion tumor in 1836 (9). MC is still one of the most difficult regions in neurosurgery.

MC is located beside the cavernous sinus. It is formed by the dura mater which is protruded from the posterior cranial fossa to the middle cranial fossa (1,3). The anatomy of this region is quite complex and fine neural and vascular structures are present around the MC. The most common tumors of this region are trigeminal schwannomas and meningiomas (7,17). Although most of them are benign lesions, they may show expansive growth and compress the important nerves and blood vessels. They may grow into the posterior fossa and form a dumbbell-shaped tumor. So, the surgical approach is difficult and has a high risk (7,17).

Many surgical approaches have been described to reach these regions and they are mainly divided into three categories: anterolateral approach, lateral approach and posterolateral approach (1,5,6,15). In the last decades, endoscopic technology has made great progress. The neuroendoscopic technique has many advantages, such as endonasal minimally invasive approach, panoramic view, close perspective, and good cosmetic result. These advantages not only allow us to complete tumor removal, but also significantly improve patients' quality of life.

There are scattered reports about endoscopic endonasal transmaxillary transpterygoid approach to MC in the literature (1,6). We also confirmed by the anatomical study and clinical use that endoscopic endonasal transmaxillary transpterygoid approach can be chosen for the tumors involving the MC. This technique also has special anatomical advantages compared to the other surgery approaches. The trigeminal nerve and its branches, which are located in the MC, are in the back to front direction, and lateral to the nasal region. So this approach can be performed parallel to the path of trigeminal nerve and its branches for the tumors involving the anterior medial part of the MC. In light of anatomical knowledge and current literature, we carried out endoscopic endonasal transmaxillary transpterygoid approach for the management of 2 cases with tumor invading the MC.

Remarkable points of this surgical technique are:

A, stage of nasal cavity: First of all, one must be familiar with nasal anatomical structures. We identified the sphenopalatine artery and the pharyngeal branches of the maxillary artery and coagulated them to reduce bleeding in order to reach the sphenopalatine foramen and palatovaginal canal. After the coagulation of the sphenopalatine artery and cutting the middle turbinate in the case with trigeminal schwannoma, the stump of middle turbinate had no obvious bleeding.

B, stage of maxillary sinus: We partly removed the posterior wall of the maxillary sinus by punch and drill. That is enough to reach the tumor site and is different from the report of Kassam et al. (6). They removed medial and posterior walls of the maxillary sinus and opened widely the maxillary sinus.

C, stage of pterygopalatine fossa: We looked for vidian nerve by the palatovaginal canal, which plays an important role in the protection of the vidian nerve. They are adjacent to the mouth of the vidian cave and palatovaginal canal in the pterygopalatine fossa, as reported by Pinheiro-Neto et al. (11). We also looked for the mouth of the palatovaginal canal in pterygopalatine fossa. After the opening of the palatovaginal canal, we found the front mouth of the vidian cave and the nerve. This can protect the vidian nerve inconvenient than previous ways. This way has been previously reported by Pinheiro-Neto et al. (11).

D, stage in the posterior wall of the pterygopalatine fossa: We looked for foramen rotundum lateral and top to the vidian nerve along the posterior wall of the pterygopalatine fossa. Then, we opened lateral to foramen rotundum so that further expansion of the surgical site can be achieved, and it can easy to find V2.

E, the vidian nerve stage: We paid attention for the protection of the vidian nerve intraoperatively, and found the internal carotid artery near the terminal part of the vidian nerve. We removed the medial bone of vidian nerve. Then we went up and down, at last, found free vidian nerve and managed the lateral bone of vidian nerve. It does not fully match with the study of Prevedello et al. (12). When they handled the bone of the vidian cave, they first left a thin bone sheath and removed it last. We mainly observed that the anatomy of this part is very complex, but it can still be managed under direct

vision in endoscopy. With open vidian canule, we can easily understand the range of surgical resection, and better avoid injury of the vidian nerve.

F, the reconstruction stage: The reconstruction was performed by the contralateral nasal septum pedicled mucosal flap in our 2 cases. No cerebrospinal fluid (CSF) leakage or other endoscopy-related complications were seen after this reconstruction.

The most important complications after endoscopic endonasal surgery are CSF leakage and intracranial infection. CSF leakage is especially difficult to deal with. Currently, the incidence of complications is significantly low with the use of vascular pedicled mucosal flap. Kassam et al. reported that the current rate of complication is less than 5% (4,8).

In our 2 cases, the tumors were in the left MC, which is quite large to expand the operation site. Once the dura mater of the quadrilateral region was incised, the tumor became visible. In the case with of trigeminal schwannoma, the operation site was too large to oppress the internal carotid artery to the medial, and then the surgical approach was also simple. Intraoperatively, we saw close adhesion of the tumor to the surrounding nerves. The handling of the tumor was quite difficult. In addition, this case had extension to the posterior cranial fossa which facilitates total resection of the tumor. This case also confirmed that endoscopic endonasal transmaxillary transpterygoid approach to Meckel's cave can also provide the tumor resection which partly extends to the posterior cranial fossa. Previously, Kassam et al. reported that the tumor parts of the posterior cranial fossa and cerebellopontine angle can be easily reached by this surgical approach (6).

Although there are many advantages of endoscopic endonasal transmaxillary transpterygoid approach, surgical decision for patients with tumors involving the MC should be based on the specific circumstances. This approach is minimally invasive with less brain retraction and has anatomical advantages to reach the anterior medial lesions of the MC and trigeminal nerve (6). The lateral approach should be chosen for the tumors located epidural part of the middle cranial fossa (16,18) The posterolateral approach should be preferred for the tumors expanding to the posterior fossa (14,15). So, preoperative examinations and discussion with strict surgical design are essential for the safety of surgery.

In addition, endoscopic techniques have a few years of history in our country. Due to economic and traditional reasons, endoscopic techniques in our country are not commonly practiced. Moreover, endoscopic surgical techniques dealing with MC is relatively difficult and postoperative reconstruction is also troublesome. This method requires adequate surgical skills and experience based on the relevant works.

The anatomical structure of MC is complex. It is therefore important to use the new navigation technologies based on the anatomical characteristics of the tumor (2,10). Intraoperative real-time navigation and the Doppler ultrasound technique may be used for the identification of important structures and blood vessels. This technique protects the vidian nerve and carotid artery. Therefore, the endoscopic approach requires navigation, intraoperative ultrasound and other related equipment, as technical support.

CONCLUSION

Endoscopic endonasal transmaxillary transpterygoid approach to the Meckel's cave provides safe surgery under direct vision without brain retraction. It is also easier to protect the surrounding neurovascular structures by this approach. Neuronavigation and intraoperative ultrasound-guided technique increase the safety of surgery.

REFERENCES

1. Bai ZQ, Cai EY, Wang SQ, Li ZJ, Wang SB: Nasal cavity-maxillary sinus-pterygopalatine fossa-Meckel's cave: A preliminary anatomic study of an endoscopy-based operative approach. Neurosci Bull 25(6):376-382, 2009
2. Del Gaudio JM: Endoscopic transnasal approach to the pterygopalatine fossa. Arch Otolaryngol Head Neck Surg 129(4):441-446, 2003
3. Ginsberg LE, De Monte F: Imaging of perineural tumor spread from palatal carcinoma. AJNR Am J Neuroradiol 19(8):1417-1422, 1998
4. Hadad G, Bassagasteguy L, Carrau RL, Mataza JC, Kassam A, Snyderman CH, Mintz A: A novel reconstructive technique after endoscopic expanded endonasal approaches: Vascular pedicle nasoseptal flap. Laryngoscope 116(10):1882-1886, 2006
5. Jian FZ, Santoro A, Innocenzi G, Wang XW, Liu SS, Cantore G: Frontotemporal orbitozygomatic craniotomy to exposure the cavernous sinus and its surrounding regions. J Neurosurg Sci 45(1):19-28, 2001
6. Kassam AB, Prevedello DM, Carrau RL, Snyderman CH, Gardner P, Osawa S, Seker A, Rhoton AL Jr: The front door to meckel's cave: An anteromedial corridor via expanded endoscopic endonasal approach- technical considerations and clinical series. Neurosurgery 64 Suppl 3:71-82, 2009
7. Kouyialis AT, Stranjalis G, Papadogiorgakis N, Papavlassopoulos F, Ziaka DS, Petsinis V, Sakas DE: Giant dumbbell-shaped middle cranial fossa trigeminal schwannoma with extension to the infratemporal and posterior fossae. Acta Neurochir (Wien) 149(9):959-963, 2007
8. Luginbuhl AJ, Campbell PG, Evans J, Rosen M: Endoscopic repair of high-flow cranial base defects using a bilayer button. Laryngoscope 120(5):876-880, 2010
9. Moiyadi AV, Satish S, Rao G, Santosh V: Multicompartmental trigeminal schwannoma--a clinical report. J Craniofac Surg 19(4):1177-1180, 2008
10. Nakamura M, Krauss JK: Image-guided resection of small lesions in the cavernous sinus and Meckel's cave. Eur J Surg Oncol 36(2):208-213, 2010
11. Pinheiro-Neto CD, Fernandez-Miranda JC, Rivera-Serrano CM, Paluzzi A, Snyderman CH, Gardner PA, Sennes LU: Endoscopic anatomy of the palatovaginal canal (palatosphenoidal canal): A landmark for dissection of the vidian nerve during endonasal transpterygoid approaches. Laryngoscope 122(1):6-12, 2012
12. Prevedello DM, Pinheiro-Neto CD, Fernandez-Miranda JC, Carrau RL, Snyderman CH, Gardner PA, Kassam AB: Vidian nerve transposition for endoscopic endonasal middle fossa approaches. Neurosurgery 67(2 Suppl Operative):478-484, 2010

13. Sabancı PA, Batay F, Civelek E, Al Mefty O, Husain M, Abdulrauf SI, Karasu A: Meckel's cave. World Neurosurg 76(3-4):335-341, 2011
14. Samii M, Carvalho GA, Tatagiba M, Matthies C: Surgical management of meningiomas originating in Meckel's cave. Neurosurgery 41(4):767-774, 1997
15. Samii M, Tatagiba M, Carvalho GA: Retrosigmoid intradural suprameatal approach to Meckel's cave and the middle fossa: Surgical technique and outcome. J Neurosurg 92(2):235-241, 2000
16. Taha JM, Tew JM Jr, van Loveren HR, Keller JT, el-Kalliny M: Comparison of conventional and skull base surgical approaches for the excision of trigeminal neurinomas. J Neurosurg 82(5):719-725, 1995
17. Verstappen CC, Beems T, Erasmus CE, van Lindert EJ: Dumbbell trigeminal schwannoma in a child: Complete removal by a one-stage pterional surgical approach. Childs Nerv Syst 21(11):1008-1011, 2005
18. Yoshida K, Kawase T: Trigeminal neurinomas extending into multiple fossae: Surgical methods and review of the literature. J Neurosurg 91(2):202-211, 1999