ORIGINAL ARTICLE

A Cranio-Orbital-Zygomatic Approach to Dumbbell-Shaped Trigeminal Neurinomas Using the Petrous Window

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ABSTRACT

We applied a cranio-orbital-zygomatic approach that extends the temporal craniotomy more posteriorly and minimizes the frontal orbitotomy of an ordinary orbitozygomatic approach in order to provide wide access to the already eroded petrous apices along the long axis of trigeminal neurinomas. We treated seven dumbbell-shaped trigeminal neurinomas between 1991 and 1998 (mean follow-up, 38 months; range, 9 to 109 months). The configuration of the tumor mass was assessed on magnetic resonance imaging by measuring its long diameter in the middle and posterior fossae and the width of petrous erosion. Tumors were then classified into five types based on their distribution over the petrous ridge. Total removal was achieved in six patients, who showed no evidence of tumor recurrence during the follow-up period. The only major complication was one case of anesthesia dolorosa. The one patient with a subtotal removal developed a recurrence 12 months after surgery, in the posterior fossa. The cranio-orbital-zygomatic approach could be an effective method for removing dumbbell-shaped trigeminal neurinomas, particularly in cases of wide petrous erosion from the tumor. If, however, the tumor has a larger posterior fossa component, this approach may not provide adequate exposure to achieve a total resection.

KEYWORDS: Dumbbell-shaped tumors, cranio-orbital-zygomatic approach, petrous bone, trigeminal neurinomas

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Trigeminal neurinomas are rare and assume various shapes according to their extension. Early conventional surgical approaches to this tumor inevitably were associated with low rates of total removal and a high incidence of postoperative complications.[1–3] With the advent of microsurgical techniques and skull base approaches, it became possible to achieve total removal of this tumor with an acceptable rate of complications.[4–6] Among the various shapes of trigeminal neurinomas, dumbbell- or hourglass-shaped tumors have been among the most difficult to resect totally through a single approach.

Various skull base approaches have been applied to this lesion with the intent of exposing both fossae through an extended craniotomy and of accessing Meckel's cave via a transpetrosal route.[4,7,8] Some of these tumors erode the petrous bone during growth. Through this natural window, the posterior fossa can be accessed via a subtemporal route without additional petrosectomy. Hence, we characterized the growth patterns of tumors over the petrous bone to establish indications for various approaches for dumbbell-shaped trigeminal neurinomas and used the classical cranio-orbital-zygomatic (COZ) approach with a bone flap designed to widen the access to the petrous window. The surgical outcomes of seven patients indicated for this approach according to our new classification are presented here. The utility of this approach is also compared to other approaches.

MATERIALS AND METHODS

Patient Population

Among 29 patients with a trigeminal neurinoma who underwent surgery at Seoul National University Hospital between 1982 and 1998, seven patients underwent a COZ approach (Table 1). All patients underwent preoperative MR imaging. The extent of tumor removal and follow-up outcomes were determined by postcontrast MR imaging. The follow-up period varied from 9 to 109 months (mean, 38 months).

Classification of Tumor

The tumors were categorized into five groups based on enhanced axial MR images. The long axis of the tumor (usually a right angle to the petrous

Table 1 Tumor Characteristics and Surgical Outcomes

Case No.	Age/ Sex	Tumor Type	Tumor Diameter (M : P) (mm)	Petrous Window	Extent of Removal	Complications	Follow-up Result
1	53/M	Mp	45 (30: 15)	12 mm	GTR	Anesthesia dolorosa	NED for 109 months
2	42/M	Mp	50 (35: 15)	29 mm	GTR	Transient diplopia	NED for 65 months
3	34/F	mp	70 (25: 45)	22 mm	STR	No	Regrowth at 10 months
4	40/M	Mp	70 (45: 25)	27 mm	GTR	Hemotympanum, Transient diplopia	NED for 23 months
5	22/F	Mp	70 (40: 30)	30 mm	GTR	Transient diplopia, Herpes labialis	NED for 36 months
6	47/M	Mp	60 (37: 23)	25 mm	GTR	Transient diplopia	NED for 9 months
7	41/F	mp	60 (35: 25)	22 mm	GTR	Transient facial palsy	NED for 15 months

M : tP = middle to posterior fossa ratio of tumor diameter; GTR = gross total removal; STR = subtotal removal; NED = no evidence of disease bone) and the width of the petrous window, which represents a portion of the tumor crossing and eroding the long axis of the petrous pyramid, were measured in the same slice showing the maximal dimension of the porus trigeminus. Then, the long axis of the tumor was divided into the diameters of both middle and posterior fossae. The trigeminal neurinomas were divided into five types according to their growth pattern into the middle and posterior fossae (Fig. 1).

1. *m type:* The tumor was confined to the middle fossa with or without extracranial extension. It originated from the peripheral branch or ganglion of the trigeminal nerve.
2. *Mp type:* The tumor was mainly in the middle fossa with a small round extension into the posterior fossa (the diameter of the middle fossa mass was larger than twice that of the posterior fossa mass). It originated from the ganglion of the trigeminal nerve.

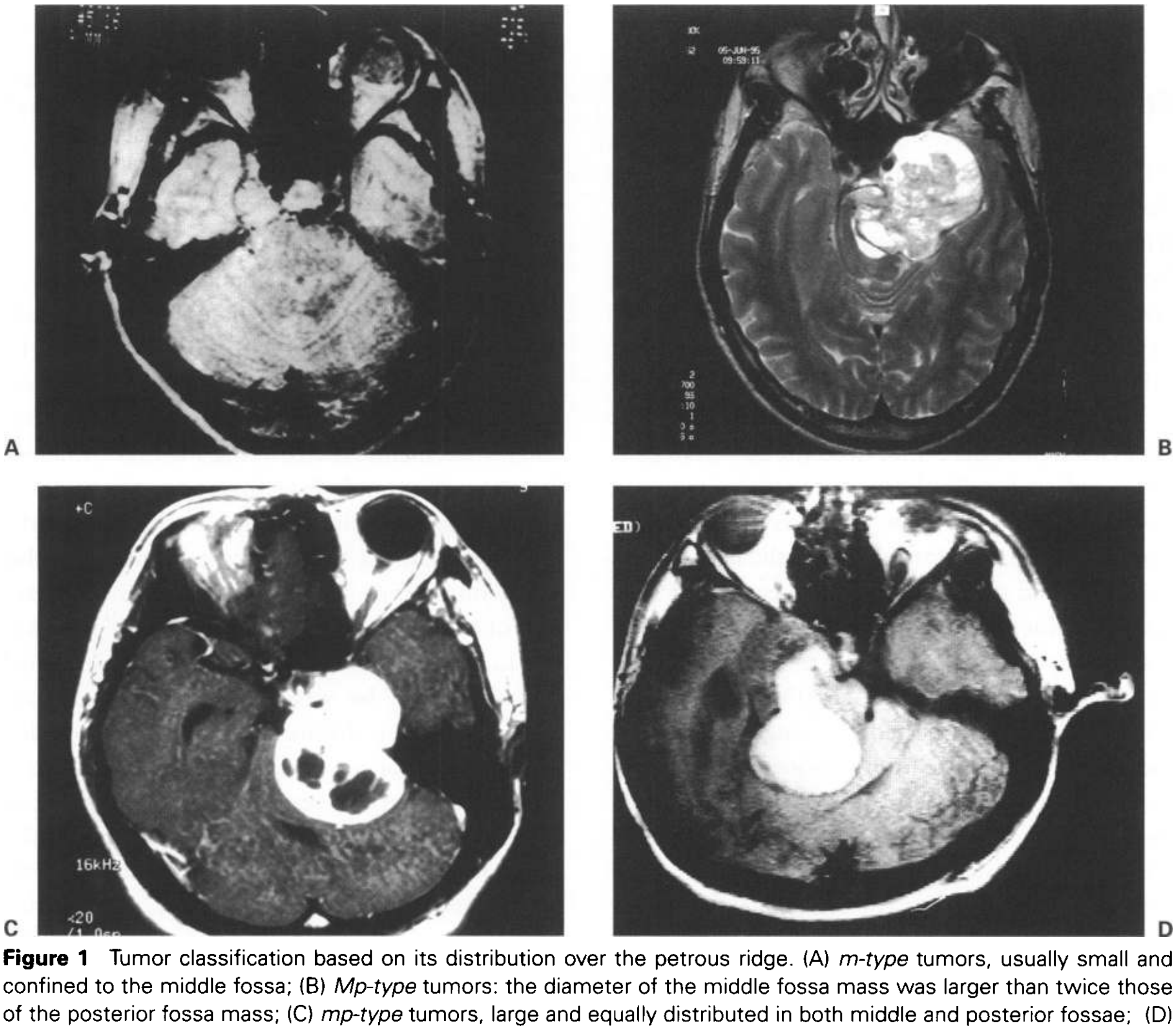

Figure 1 Tumor classification based on its distribution over the petrous ridge. (A) *m-type* tumors, usually small and confined to the middle fossa; (B) *Mp-type* tumors: the diameter of the middle fossa mass was larger than twice those of the posterior fossa mass; (C) *mp-type* tumors, large and equally distributed in both middle and posterior fossae; (D) *Pm-type* tumors: the diameter of the posterior fossa mass was larger than twice those of the middle fossa mass.

3. *mp type:* The tumor mass was about equally distributed in both the middle and posterior fossae with the long axis of the tumor crossing the petrous apex. It originated from the root or ganglion of the trigeminal nerve.
4. *Pm type:* The tumor was mainly in the cisternal space of the posterior fossa with a slender, barely round, extension into Meckel's cave. It originated from the root of the trigeminal nerve.
5. *p type:* The tumor was completely in the posterior fossa with an indiscernible extension into Meckel's cave. It originated from the root of the trigeminal nerve.

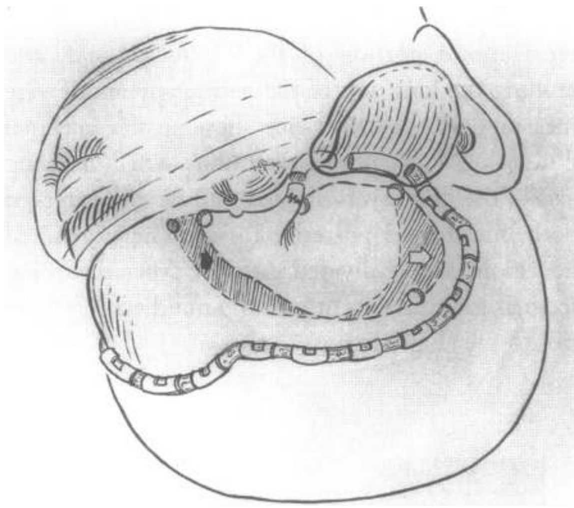

Figure 2 Drawing depicting the modified frontotemporal craniotomy combined with orbitozygomatic osteotomy. Black arrow represents the decreased extent of craniotomy, and white arrow shows the extended area of craniotomy.

Cranio-Orbital-Zygomatic Approach

Various anterolateral approaches to skull base lesions using a cranio-orbital bone flap with or without zygomatic osteotomy have been described by many neurosurgeons.[4,7,9,10–12,13] The concepts and routine procedures of our approach are similar to the classical COZ approach of Al-Mefty and others.[9,10]

The goals are to provide a wide workspace for dissection of the tumor from the gasserian ganglion and to handle the posterior fossa mass via the petrous bone window. The bicoronal incision runs along the anterior margin of the earlobe and curves around the top of the ear to end at the subtemporal line of the opposite side. The temporal craniotomy extends posteriorly to provide an adequate corridor to access Meckel's cave (Fig. 2). The bone flap is harvested as a single unit. Thus, the osteotomy between the inferior orbital fissure and the frontal process of the zygomatic arch should be done before the osteotomy of the orbital wall so that the surgeon can feel the cutting of the thin orbital wall. After the free bone flap is removed, the temporal base is drilled out to the foramen spinosum.

The tumor in the middle fossa mass can be resected either extradurally or intradurally. The authors prefer an intradural approach unless the tumor extends extracranially because CSF drainage from the Sylvian fissure facilitates safe temporal lobe retraction. Also, compared with the extradural approach, dural repair is easier. The dissection plane is made by cutting into the thin outer dural membrane covering the mass. Internal decompression and dissection proceed until the gasserian ganglion is identified on the floor of the operative field. At this time, the surgical corridor of the microscope is adjusted for better visualization of the posterior fossa mass, which lies posterior to the ganglion. Although the whole cisternal portion cannot be viewed through the petrous window, neither drilling of the already eroded petrous apex nor resection of the worn-out tentorium is necessary to remove the remaining mass (Fig. 3). A careful dissection proceeds around the ganglion under the wide exposure made by the already removed middle fossa portion and extended craniotomy. Further decompression followed by cutting off the simple arachnoid adhesion enables the mobilization of the posterior fossa mass. The remaining tumor is pulled from the posterior fossa.

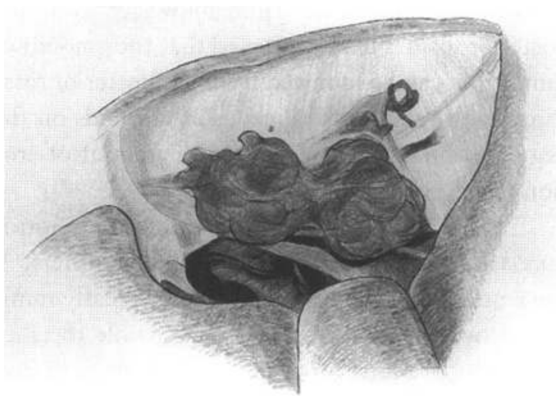

Figure 3 Illustration of the operative field represents the visualization of the posterior fossa mass through the petrous window, which was made naturally by tumor erosion of the petrous apex.

RESULTS

In six patients, the tumor was totally resected using the COZ approach. These patients usually had Mp-type tumors. In the seventh patient, the tumor was subtotally removed because it had a larger posterior fossa component than middle fossa portion (Case 3). This tumor was borderline between the Mp and Pm types.

The most frequent postoperative complication was transient diplopia due to sixth cranial nerve palsy, which was detected in four patients. Transient facial palsy occurred in one patient 1 week after surgery without immediate dysfunction. We interpreted this as Bell's palsy rather than as being related to intraoperative manipulation. No CSF leakage occurred. In one patient, ear canal bleeding due to incidental opening of large supramastoid air cells was managed for 2 weeks. The only permanent morbidity was anesthesia dolorosa (Case 1). At the operative field of this patient, the fanned-out rootlets had lain over the mass laterally so that most of them were severed during the tumor removal despite careful dissection.

No evidence of recurrence was found on imaging at last follow-up (mean, 43 months) in patients who underwent total removal. The patient with the subtotal resection underwent a second operation for symptomatic regrowth 10 months after surgery. At the second operation, the tumor had become a Pm type. An attempted retromastoid approach failed to remove the tumor totally. The patient is followed regularly on an outpatient basis.

DISCUSSION

Various surgical approaches have been used to resect trigeminal neurinomas according to their size, shape, and location. At one time these tumors were considered among the most difficult to resect totally without incurring major morbidity.[2,3] With the evolution of microsurgery and skull base approaches, the rate of total removal has increased to 90% without serious complications.[1,6,8,11,13–17] However, no single approach is suitable for every patient who presents with a trigeminal neurinoma. The authors used the COZ approach with a craniotomy designed to be more suitable for patients showing characteristic growth patterns on preoperative MR imaging.

Tumor Classification and Indication

The few classifications of trigeminal neurinomas reflect different perspectives. Jefferson[18] classified tumors according to their location: middle fossa type, posterior fossa type, and dumbbell-shaped type. Lesoin et al.[15] proposed a classification based on origin: roots in the posterior fossa, the gasserian ganglion, and the trigeminal branches. They insisted their classification was useful in choosing a surgical approach. However, it is difficult to differentiate the origin when the tumor is large enough to extend into multiple fossae, although these tumors may originate in any portion of the nerve between the root and the peripheral branches.[6,15,19]

Recently, we used a modified classification based on tumor location and extension. This modification included the fourth tumor type that originated from a major division of the trigeminal nerve and extended extracranially. This tumor type (described as "peripheral type" by Day et al.[14] and as "extracranial type" by Samii et al.[8]) deserves mention because it is suitable for extradural approaches. Our new classification focuses on the pattern of distribution over the petrous bone window as viewed in MR images. This classification provides valuable information about the resectability of a trigeminal neurinoma through the subtemporal route. Theoretically, all m, Mp, and mp types ("mainly in the middle fossa" and "dumbbell" of other authors) could be relative indications for a COZ approach. In practice, small m-type tumors (< 3cm) without cavernous sinus invasion can be resected through a simple subtemporal approach. However, with the subtemporal approach, it is difficult to handle profuse bleeding from the cavernous sinus and excessive brain retraction is necessary for a large middle fossa mass. The COZ approach traces the mass from the middle fossa to posterior fossa. Some mp-type tumors with a predominantly posterior fossa mass or narrow petrous bone window are difficult to remove totally by this approach. Thus, large m-type tumors with or without cavernous sinus invasion, all Mp-type tumors, and mp-type tumors with a predominantly middle fossa mass and a wide petrous window may be considered absolute indications for this approach.

Usefulness of the COZ Approach

As described earlier, the variety of locations and shapes of trigeminal neurinomas makes it difficult to compare the efficacy of individual approaches. In addition, patients' postoperative functional outcomes as a function of approach are rarely reported. Many authors described the obstacles to total removal as invasion of the cavernous sinus, adherence to vital structures, and inadequate exposure.[6,8,13,15] As McCormick[6] described earlier, a subtemporal intradural approach could provide an excellent exposure of the middle fossa and allow access into the posterior fossa. He also stressed that the amount of tumor that can be removed from the posterior fossa through the subtemporal exposure depends on the degree of brain relaxation and the amount of erosion of the petrous apex.

Through the cranio-orbital approach, introduced and popularized by Al-Mefty and others,[9,10] the amount of brain retraction can be greatly minimized by following the shortest possible distance (via multiple routes) to access large lesions in juxtasellar areas and those that extend into the cavernous sinus along the tentorial notch. Thus, the COZ approach to the trigeminal neurinomas in the middle fossa can provide a wider exposure with less brain retraction than the conventional subtemporal or pterional approach.

Additionally, the COZ approach can provide the shortest route to Meckel's cave by extending the craniotomy and a wide access to a posterior fossa mass by using the already eroded petrous window. Having this relatively wide working space and keeping the dissection plane along the tumor axis help to reduce the rootlet damage that causes anesthesia dolorosa. The mass in the posterior fossa can be mobilized easily and removed after internal decompression without needing an additional exposing procedure (i.e., division of tentorium) because the tumor is usually covered with intact arachnoid membrane and does not adhere to neurovascular structures in the posterior fossa. In mp-type tumors, it is unlikely that total removal can be achieved by this approach, particularly when the petrous window size is smaller than the diameter of the posterior fossa mass. However, the relatively small-sized petrous window is not an absolute contraindication for this approach because the hidden portion of the posterior fossa mass can be mobilized by internal decompression (Case 7). In Pm-type tumors, it is almost impossible to remove the posterior fossa mass totally using the COZ approach because the posterior fossa mass is large enough to lie behind the petrous bone and to escape from the various viewing angles of the surgical microscope. A combined petrosal approach[8,11,14,19–21] might be useful for such Pm- and mp-type tumors.

Nevertheless, this approach has some disadvantages when applied to large dumbbell-shaped tumors. First, the surgeon traces the tumor not along the natural tumor axis but at a right angle to the tumor. Thus, Meckel's cave, lying at a right angle to the operative view, should be opened first for tumor removal. Dissection of the trigeminal rootlet starts from the posterior portion, which is more vulnerable to injury. Second, the procedure is somewhat elaborate and time-consuming, requiring a retrolabyrinthine-petrosectomy and transsection of the tentorium. Third, subtemporal exposure can be severely limited by the anteriorly placed vein of Labbé. An anterior transpetrosal-transtentorial approach might provide an excellent corridor to posterior fossa lesions while overcoming the listed disadvantages of the combined petrosal approach.[5] Many authors, however, have noted that this approach alone provides inadequate space to remove a large trigeminal neurinoma. Therefore, it should be combined with other approaches to gain a better exposure.[14,19] Trigeminal neurinomas that extend into both the middle and posterior fossae can be removed totally by the COZ approach, as long as patients are selected carefully.

CONCLUSION

The COZ approach, which extends the temporal craniotomy posteriorly, can be an effective method for removing trigeminal neurinomas that extend into both the middle and posterior fossae with minimal brain retraction and fewer complications. We classified tumor types to permit careful selection of cases, stressing the distribution of the mass over the petrous window and the size of the petrous bone window. For most dumbbell-shaped trigeminal neurinomas, with the exception of those with larger posterior fossa components, this approach could be a primary choice for total tumor removal.

COMMENTS FOR PUBLICATION

In this interesting article, the authors describe their experience using a modified orbitozygomatic osteotomy and pterional craniotomy for resecting dumbbell-shaped trigeminal neurinomas. They extend the pterional craniotomy to increase access to the middle fossa. With this additional exposure, they were able to achieve total resection in six of their seven cases. At our institution, we, too, favor skull base approaches for lesions of this nature and, in particular, at this location. Although the orbitozygomatic osteotomy increases bone removal, it minimizes brain retraction and facilitates removal of the tumor. Any strategy that can be implemented to minimize injury to normal brain tissue should be undertaken.

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REFERENCES

1. Bordi L, Compton J, Symon L. Trigeminal neuroma. A report of eleven cases. Surg Neurol 1989;31:272–276
2. Cushing H, Eisenhardt L. Meningiomas: Their Classification, Regional Behavior, Life History and Surgical End Results. Springfield, IL: Charles C Thomas; 1938
3. Schisano G, Olivercrona H. Neurinomas of the gasserian ganglion and trigeminal root. J Neurosurg 1960;17:306–322
4. Hakuba A, Liu S, Nishimura S. The orbitozygomatic infratemporal approach: a new surgical technique. Surg Neurol 1986;26:271–276
5. Kawase T, Shiobara R, Toya S. Anterior transpetrosal-transtentorial approach for sphenopetroclival meningioma: surgical method and results in 10 patients. Neurosurgery 1991;28:869–876
6. McCormick PC, Bello JA, Post KD. Trigeminal schwannoma. Surgical series of 14 cases with review of the literature. J Neurosurg 1988;69:850–860
7. Hakuba A, Tanaka K, Suzuki T, Nishimura S. A combined orbitozygomatic infratemporal epidural and subdural approach for lesions involving the entire cavernous sinus. J Neurosurg 1989;71:699–704

8. Samii M, Migliori MM, Tatagiba M, Babu R. Surgical treatment of trigeminal schwannomas. J Neurosurg 1995; 82:711–718
9. Al-Mefty O. Supraorbital-pterional approach to skull base lesions. Neurosurgery 1987;21:474–477
10. Bowels AP Jr, Anand VK. Cranioorbital approach. In: Donald PJ. Surgery of the Skull Base. Philadelphia: Lippincott-Raven; 1998: 263–286
11. Yasui T, Hakuba A, Kim SH, Nishimura S. Trigeminal neurinomas: operative approach in eight cases. J Neurosurg 1989;71:506–511
12. Sekhar LN, Swamy NK, Jaiswal V, Rubinstein E, Hirsch WE Jr, Wright DC. Surgical excision of meningiomas involving the clivus: preoperative and intraoperative features as predictors of postoperative functional deterioration. J Neurosurg 1994;81:860–868
13. Pollack IF, Sekhar LN, Jannetta PJ, Janecka IP. Neurilemmomas of the trigeminal nerve. J Neurosurg 1989;70: 737–745
14. Day JD, Fukushima T. The surgical management of trigeminal neuromas. Neurosurgery 1998;42:233–241
15. Konovalov AN, Spallone A, Mukhamedjanov DJ, Tcherekajev VA, Makhmudov UB. Trigeminal neurinomas: a series of 111 surgical cases from a single institution. Acta Neurochir (Wien) 1996;138:1027–1035
16. Lesoin F, Rousseaux M, Villette L, et al. Neurinomas of the trigeminal nerve. Acta Neurochir (Wien) 1986;82: 118–122
17. Visot A, Dermoe P, de Leon JLM. Sphenocavernous and infratemporal trigeminal neurinomas: surgical series of 15 cases. Skull Base Surg 1992;2:142–149
18. Jefferson G. The trigeminal neurinoma with some remarks on malignant invasion of the gasserian ganglion. Clin Neurosurg 1955;1:11–54
19. 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 1995;82:719–725
20. Spetzler RF, Daspit CP, Pappas CT. The combined supra- and infratentorial approach for lesions of the petrous and clival regions: experience with 46 cases. J Neurosurg 1992;76:588–599
21. Tancioni F, Gaetani P, Villani L, Zappoli F, Rodriguez Y, Baena R. Neurinoma of the trigeminal root and atypical trigeminal neuralgia: case report and review of the literature. Surg Neurol 1995;44:36–42