HAYDARPAŞA NUMUNE MEDICAL JOURNAL

DOI: 10.14744/hnhj.2022.45712
Haydarpasa Numune Med J 2023;63(1):62–67

hnhtipdergisi.com

ORIGINAL ARTICLE

Retrospective Evaluation of the Effect of Surgery and CyberKnife on Recurrence and Neurological Deficits in Cases Diagnosed as Vestibular Schwannoma

Mehmet Alpay Çal, Haydar Gök

Department of Neurosurgery, Istanbul Prof. Dr. Cemil Tascioglu City Hospital, Istanbul, Türkiye

Abstract

Introduction: We aimed to investigate the effects of treatment with microsurgical resection and CyberKnife, on local control and functional neurological loss in patients diagnosed as vestibular schwannoma and to choose the best treatment method for the benefit of the patient.

Methods: Thirty-one patients were included in the study. Microsurgical resection was performed in 15 (Group 1) patients, and CyberKnife treatment was performed in 16 (Group 2) patients. Microsurgical resection with retrosigmoid approach was performed as a surgical method for Group 1 patients, accompanied by electrophysiological studies. Stereotaxic radiosurgery was performed with CyberKnife in Group 2 patients whom with tumors smaller than 3 cm and risk of additional morbidity. All patients were followed up clinically and radiologically.

Results: The mean tumor diameter was 32.7±8.02 mm in Group 1 patients and 17.6±6.1 mm in Group 2 patients. The mean follow-up period was 33.8±16.3 months in Group 1 and 16.4±7.5 months in Group 2. The local control success of microsurgical resection in vestibular schwannomas was 100%, and the CyberKnife treatment was 93.75%. Good to moderate facial nerve function was preserved in 80% of Group 1 patients. In Group 2, the rate of complete preservation of facial nerve functions is 100%. While the rate of complete loss of hearing function was 6.67% in Group 1, no deterioration in hearing function was observed in Group 2.

Discussion and Conclusion: Microsurgical resection is inevitable in large-sized vestibular schwannomas due to the mass effect. The application of surgery accompanied by electrophysiological studies reduces neurological deficits. Functional losses may occur even in the presence of electrophysiological studies. In large and giant tumors, applying microsurgical resection with electrophysiological studies and providing local control with CyberKnife as an adjuvant treatment in the presence of residual tumor are seen as the ideal treatment method.

Keywords: Functional neurosurgery; local control; retrosigmoid approach; vestibular schwannoma

Vestibular schwannoma is the most common tumor of the cerebellopontine angle. It is an extra-axial mass and when it reaches large dimensions, it can compress the brain stem, cerebellum, and fourth ventricle. After diagnosis, follow-up, microsurgical resection, or stereotaxic radiation therapy, options are offered according to the tumor size and the clinical status of the patient. Stereotactic radiation therapy emerges as a necessity due to neurological deficits that may be encountered after microsurgical resection or other surgical risks of the patient. CyberKnife, which

Correspondence (İletişim): Haydar Gök, M.D. Department of Neurosurgery, Istanbul Prof. Dr. Cemil Tascioglu City Hospital, Istanbul, Türkiye
Phone (Telefon): +90 506 309 29 65 **E-mail (E-posta):** haydarctf@hotmail.com
Submitted Date (Başvuru Tarihi): 25.07.2022 **Revised Date (Revize Tarihi):** 03.08.2022 **Accepted Date (Kabul Tarihi):** 08.08.2022

has the latest technology among many existing stereotaxic radiation therapy tools, is a preferred treatment application for both the patient and the physician due to its ease of use and wider usage areas.

In this study, we aimed to compare the effects of microsurgical resection and CyberKnife treatment on recurrence and neurological deficits in cases with vestibular schwannoma and to choose the appropriate treatment method for patients.

Materials and Methods

Thirty-one patients were included in the study. Tumor sizes were calculated in three dimensions by performing MRI on all patients and were evaluated using the widest diameter in the analyses. The intracanalicular part of the tumor is included in the maximal transverse diameter. For the evaluation of hearing, audiometric tests were performed before and after treatment and evaluated according to the Gardner-Robertson classification[1]. V, VII, and VIII. Nerves were evaluated clinically before and after treatment. Trigeminal nerve functions were examined in three semiquantitative classifications as normal sensory, decreased sensory, and complete sensory loss. Facial nerve functions were evaluated according to the House-Brackmann classification[2].

Microsurgical resection was performed in 15 (Group 1) patients and CyberKnife treatment was applied in 16 (Group 2) patients. The patients who were decided to have surgery considering tumor size, neurologic, and clinical conditions were operated with the standard retrosigmoid approach. None of them had previous surgery and all patients underwent a single surgical intervention (Fig. 1).

Stereotaxic radiosurgery treatment with CyberKnife (SRC) was applied for vestibular schwannomas smaller than 3 cm in diameter. The decision on which patients to apply SRC is made by the council, which is attended by neurosurgeons, oncologists, radiologists, and otolaryngologists. Three of the patients received radiosurgical treatment with a single dose of 12 Gy irradiation, and 13 received radiation treatment with 3×6 Gy (total 18 Gy) irradiation divided into three fractions (Fig. 2).

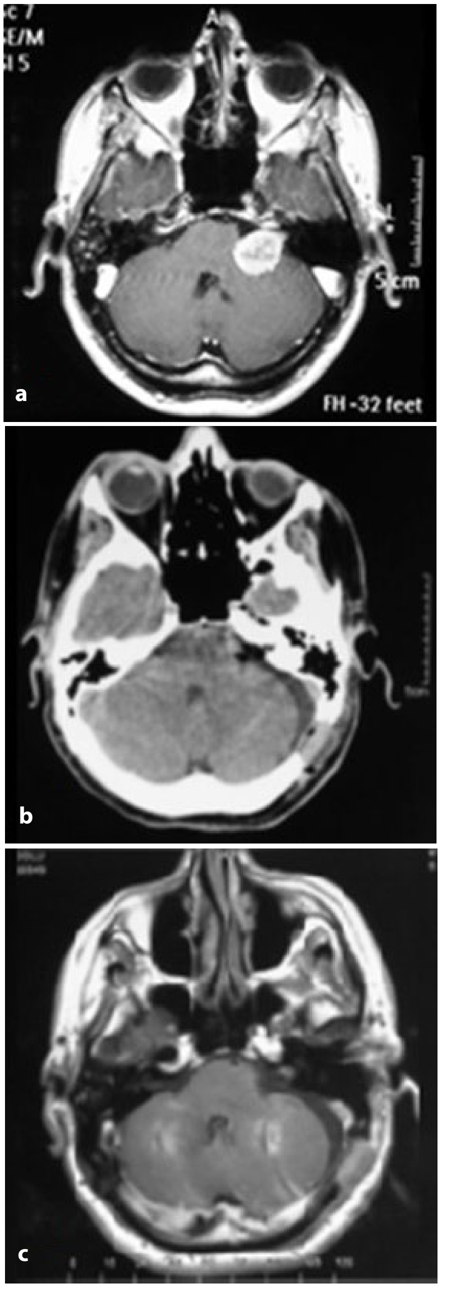

Figure 1. (a) Axial T1W MR with pre-operative contrast, **(b)** post-operative early period control brain CT, **(c)** axial T1W MR images with post-operative early period contrast are shown in a patient who underwent microsurgical resection. The tumor was completely removed.

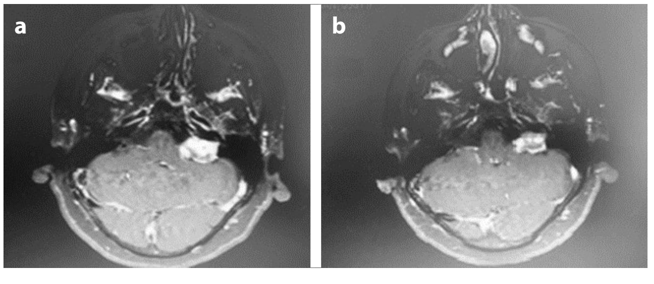

Figure 2. (a) Axial T1W MR images with preoperative contrast, **(b)** 18 months later axial T1W MR images with control contrast of a patient who underwent stereotaxic radiosurgery with CyberKnife. Tumor size appears to be reduced .

Statistical Analysis

Statistical analyzes were made based on the evaluation of the obtained data in histographic tables and the symptoms were based on the t-test method.

This study was found ethically appropriate according to the decision numbered 140 of the Okmeydanı Training and Research Hospital Clinical Research Ethics Committee.

Results

The characteristics of the patients evaluated as two treatment groups are summarized in Table 1. Symptoms in patients were divided into stageable and visual analog symptoms (VAS). Treatment-related stageable complications were evaluated as progression of an existing or newly developed loss of function. For the symptoms evaluated with the VAS score, complications were evaluated by taking the increase in the complaints of the patients. The symptoms were evaluated as pre-operative and post-operative symptoms by t-test statistical analysis method and summarized in Table 2. Complication rates are summarized in Table 3.

In Group 1 patients, 80% loss of facial nerve function was detected, according to any grade of the Gardner-Robertson classification. No loss of facial nerve function was observed in any of the Group 2 patients. Progressive loss of hearing function was detected in 10 (66.67%) patients in Group 1 and only in one (6.25%) patient in Group 2. In Group 1, facial hypoesthesia was detected in 3 patients (20%), progressive tinnitus in 3 patients (20%), and headache in 2 patients (13.33%). In Group 2, facial hypoesthesia was detected in 2 patients (12.50%), progressive tinnitus in 6 pa-

Table 1. Population characteristics of patients who received microsurgical resection and CyberKnife treatment with the diagnosis of vestibular schwannoma

	Group 1	Group 2
Number of Patients	15	16
Mean Age (years)	40.5±13.4	56.4±12.7
Male: Female	7:8	10:6
Right: Left (Tumor Side)	7:8	7:9
Tumor Size (mm)	32.7±8.02	17.6±6.1
Single Dose SRC	-	3
Fraction SRC	-	13
Follow-up Time (months)	33.8±16.3	16.4±7.5

Table 3. Complications detected according to treatment groups in patients with vestibular schwannoma

Complications	Group 1		Group 2	
	n	%	n	%
CSF Fistula	2	13.33	0	0.00
Facial Paralysis	12	80.00	0	0.00
Facial Hypoesthesia	3	20.00	2	12.50
Tinnitus	3	20.00	6	37.50
Hearing Loss	10	66.67	1	6.25
Diplopia	0	0.00	0	0.00
Cerebellar Edema	0	0.00	0	0.00
Hydrocephalus	1	6.67	0	0.00
Hematoma	3	20.00	0	0.00
Cerebellar Ataxia	0	0.00	0	0.00
Meningitis	2	13.33	0	0.00
Headache	2	13.33	8	50.00
Nausea-vomiting	1	6.67	0	0.00
Deep Vein Thrombosis	0	0.00	1	6.25

Table 2. Statistical analysis (t-test) of the symptoms of patients diagnosed with vestibular schwannoma according to Group 1 and Group 2, according to their pre- and post-operative conditions

Symptoms	Group 1					Group 2				
	Presurgery		Postsurgery		Change	PreSRC		PostSRC		Change
	n	%	n	%	%	n	%	n	%	%
Hearing Loss	12	80.00	14	93.33	↑13.33	13	81.25	13	81.25	0.00
Facial Paralysis	0	0.00	12	80.00	↑80.00	0	0.00	0	0.00	0.00
Tinnitus	8	53.33	3	20.00	↓33.33	7	43.75	6	37.50	↓6.25
Imbalance	8	53.33	4	26.67	↓26.67	6	37.50	4	25.00	↓12.50
Headache	12	80.00	2	13.33	↓66.67	8	50.00	9	56.25	↑6.25
Facial Hypoesthesia	4	26.27	3	20.00	↓6.67	1	6.25	3	15.75	↑12.50
Epilepsy	1	6.67	0	0.00	↓6.67	0	0.00	0	0.00	0.00
Dysphagia	0	0.00	1	6.67	↑6.67	0	0.00	0	0.00	0.00
Nausea-vomiting	5	33.33	0	0.00	↓33.33	0	0.00	0	0.00	0.00
Taste Disorder	1	6.67	0	0.00	↓6.67	0	0.00	0	0.00	0.00

tients (37.50%) and headache 8 patients (50%). Headache became permanent in 2 patients (13.33%) in Group 1, except for surgery-related pain. In Group 2, it showed a transient increase in the early period of treatment in 8 patients (50%). In addition, complications such as cerebrospinal fluid (CSF) discharge (13.33%), hydrocephalus (6.67%), hematoma (20%), and meningitis (13.33%) were observed as surgical complications in the Group 1, but none of them required additional surgical intervention. In Group 2, heart failure and post-treatment deep vein thrombosis were detected in 1 patient (6.25%) with coronary stenting as a morbidity factor.

According to Yaşargil classification, vestibular schwannomas with a diameter of <2 cm are defined as small, tumors between 2 and 4 cm as medium, and with a diameter of >4 cm as large[3]. In Group 1, the tumor was medium in 12 (80%) patients and a post-operative 8 mm residue remained in one patient. The other 3 (20%) patients had a large tumor size and 2 patients (66.7%) had post-operative 12 mm and 13 mm residuals. The mean follow-up period was 33.8±16.3 months and no recurrence was detected within this period. Hence, in vestibular schwannomas, the success of microsurgical resection for local control of the tumor was 100%.

In Group 2, 1 patient (6.25%) had a small tumor, 12 patients (75%) had a medium tumor, and 3 patients (18.75%) had a large tumor. During the follow-up period of 16.4±7.5 months, tumor size regression was detected in 10 patients (62.5%), while the tumor was stable in 5 patients (31.25%). Tumor progression was detected in only one patient (6.25%). The local control success rate of CyberKnife treatment was evaluated as 93.75%.

Discussion

Vestibular schwannomas are the most common tumor of the cerebellopontine angle and constitute approximately 9% of all intracranial tumors[4]. Most of these tumors arise from the Obersteiner-Redlich zone, 8–12 mm distal to the brainstem, near the porus acousticus. This described zone marks the neurilemmal layer at the junction of central and peripheral myelin in the superior branch of the vestibular nerve. They are often sporadic, benign, and generally slow growing tumors, and they can localize bilaterally in patients with a rare autosomal dominant disease neurofibromatosis Type 2[5]. Patients diagnosed with vestibular schwannoma most often apply with complaints of hearing loss, tinnitus, imbalance, and headache. The prediagnosis is usually due to asymmetric sensorineural hearing loss or other cranial nerve deficits proven by audiometry. In the presence of these symptoms, computed tomography or magnetic resonance imaging, studies are performed. About 80–90% of posterior fossa lesions detected in this way are observed as vestibular schwannoma[6].

Dr. Harvey Cushing[7] made the diagnosis of vestibular schwannoma by seeing the clinical appearance of the cerebellopontine corner and the enlargement of the internal acoustic canal on the radiograph, and operated on, and these tumors were large tumors. Dr. Walter Dandy,[8] on the other hand, published the results of operations performed with the retrosigmoid suboccipital approach in 1941. In the second half of the 20th century, microsurgery and stereotaxic radiosurgery were introduced in the treatment of vestibular schwannoma. In 1962, Dr. W House[9] applied the translabirintine approach with microsurgery to preserve the facial nerve. The birth of auditory evoked potential in 1970, computed tomography in 1973 and magnetic resonance imaging in 1982 formed the cornerstones of the process. The aim of vestibular schwannoma surgery to preserve functional hearing and facial nerve reflects advances in tumor surgery. The translabyrinthine and the suboccipital (retrosigmoid) approaches can be used for all tumor sizes. However, the middle cranial fossa approach is useful only for removal of small intracanalicular tumors. The ideal approach is chosen based on criteria such as tumor size, tumor extension, pre-operative hearing level, and the surgeon's experience. In 1969, Dr. Lars Leksell[10] applied the GammaKnife Stereotaxic radiosurgery approach for the 1st time in the treatment of vestibular schwannoma. The treatment aims to achieve long-term tumor control and to preserve the function of cranial nerves. Using low prescription doses, GK treatment offers high-tumor control with low morbidity. As a result of current developments in diagnosis and treatment methods, patients with vestibular schwannoma can be diagnosed when they are still small. This situation has focused the main purpose of surgical resection on the preservation of hearing. Because vestibular schwannoma is rarely a life-threatening diagnosis, the main goal of treatment is to achieve local control and preserve organ functions. Compared to surgery, modern radiotherapy techniques offer a non-invasive treatment option in which similar local control rates are achieved, hearing and fifth and seventh cranial nerves are better preserved[11]. Treatment methods vary according to the size of the tumor, age, general condition of the patient, hearing condition, the chance of preservation of the fifth and seventh nerves, the growth rate of the tumor, the presence of NF Type 2, the adequacy of local control, and the side effects. Bakkouri et al.[12] reported that the average annual growth rate of the lesions was 1.2 mm. Current treatment approaches are close observing, stereotaxic radiosurgery, fractionated radiotherapy, and microsurgical resection. Microsurgical resection options for vestibular schwannomas are retromastoid, subtemporal, or translabirintine approaches[13-15]. In this study, retrosigmoid intervention was applied to all patients who underwent microsurgical resection.

According to the literature reviews, near total or wide subtotal resection of the tumor positively affects functional outcomes together with an acceptable tumor control[16]. Surgical morbidities such as hearing loss, facial weakness, and vestibular disorders are associated with tumor size. Facial nerve functions can also be preserved in patients with large tumors and adequate hearing can be preserved in most patients[17-19]. Intraoperative facial nerve and hearing function monitoring contribute to the surgical outcome by warning the surgeon of possible damage[18]. In this study, electrophysiological studies and neuromonitoring were performed during the operation for all patients who underwent microsurgical resection.

Although cranial nerve functions are preserved by neuromonitoring in microsurgical resection, it is possible to see surgical complications in addition to the complications seen in the CyberKnife applied patient group. The most common post-operative complications in the retrosigmoid approach are; CSF leakage, meningitis, facial paresis, headache, hearing loss, imbalance, vertigo, tinnitus, cerebellar and brainstem injuries, abscess, vascular complications, and venous air embolism[20]. Persistent headaches are a complication following surgery and are more common in retrosigmoid approaches[21,22].

Stereotaxic radiosurgery (SRC) refers to the application of a single dose of high radiation to the radiographically sized lesion to reduce damage to the structures around the lesion. Application is made with GammaKnife or linear accelerator. Cyberknife is a device that has come to the fore among SRC options today. Since there is no need to place a stereotaxic frame on the patient's head, it is superior to the conventional gammaknife device and LINAC-based systems in terms of patient comfort, and it provides the opportunity to achieve biologically better treatment responses due to treatment reproducibility (fractional dosing). There is a CyberKnife device that has been serving since 2013 in Okmeydanı Training and Research Hospital, and it is also used in the stereotaxic radiosurgery treatment of vestibular schwannomas[23]. This application is suitable for tumors <3 cm in diameter or for patients with large tumors who cannot undergo surgical treatment. Radiosurgery for solitary vestibular schwannomas appears to be the most appropriate choice for those with a cisternal diameter of <30 mm[24].

Treatment of large vestibular schwannomas can be planned in combination with subtotal resection with neuromonitoring and then radiosurgery for the residual. This combined approach provides the best local control of the tumor as well as the best functional outcome achievable. According to the study of Iwai et al.[25] in 2003 on the combined approach for vestibular schwannomas, the preservation rate of the facial nerve is 85.7% and local control is excellent. In 2008, Fuentes et al.[26] reported that tumor local control was 100% with a combined approach and the rate of facial nerve function at the House Brackmann Stage 1–2 level was 87.5%, while this rate remained 50% in radical surgery.

In small and medium-sized tumors, local control of the tumor is excellent with CyberKnife treatment and the rate of functional loss is significantly lower compared to microsurgery. However, microsurgical resection is clinically inevitable in large and giant tumors due to the mass effect. With surgical decompression, local control of the tumor is achieved and the mass effect of the tumor is eliminated. On the other hand, when total resection is aimed, microsurgical resection may result in functional loss even in the presence of electrophysiological studies. Therefore, in large and giant tumors, near-total resection accompanied by electrophysiological studies and the continuation of local control of the residual tumor with CyberKnife as an adjuvant treatment seems to provide the best functional neurological outcome for the patient.

Ethics Committee Approval: This study was found ethically appropriate according to the decision numbered 140 of the Okmeydanı Training and Research Hospital Clinical Research Ethics Committee (05/11/2013).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: M.A.Ç.; Design: M.A.Ç., H.G.; Data Collection or Processing: M.A.Ç., H.G.; Analysis or Interpretation: M.A.Ç., H.G.; Literature Search: H.G., M.A.Ç.; Writing: M.A.Ç., H.G.

Conflict of Interest: None declared.

Financial Disclosure: The authors declared that this study received no financial support.

We would like to thank to Associate Professor Suat Erol Çelik for his support and contributions.

References

1. Gardner G, Robertson JH. Hearing preservation in unilateral acoustic neuroma surgery. Ann Otol Rhinol Laryngol 1988;97:55–66. [CrossRef]
2. House JW, Brackmann DE. Facial nerve grading system. Otolaryngol Head Neck Surg 1985;93:146–7. [CrossRef]
3. Yaşargil MG. Acoustic neurinomas. Microsurgery. New York: George Thieme Verlag 1996. p.100–19.
4. Nascentes SM, Paulo EA, de Andrade EC, da Silva AL, Vassoler TM, Scanavini AB. Sudden deafness as a presenting symptom of acoustic neuroma: Case report. Braz J Otorhinolaryngol 2007;73:713–6. [CrossRef]
5. Ho SY, Kveton JF. Acoustic neuroma. Assessment and management. Otolaryngol Clin North Am 2002;35:393–404. [CrossRef]
6. Greenberg MS. Acoustic Neuromas. In: Greenberg MS, editor. Handbook of neurosurgery. 6th ed. New York, Ontario: Thieme; 2006. p.429–38.
7. Cushing HW. Intracranial tumors: Notes upon a series of two thousand verified cases with surgical-mortality percentges pertaining thereto, ıntracranial tumours: Notes upon a series of two thousand verified cases with surgical-mortality percentges pertaining. Illinois: Springfield; 1932. p.69–79.
8. Dandy WE. Results of removal of acoustic tumors by the unilateral approach. Arch Surg 1941;42:1026–33. [CrossRef]
9. House WF. Translabyrinthine approach. In: House WF, Luetje CM editors. Acoustic Tumors. Baltimore: University Park Press; 1979. p.43–87.
10. Leksell L. A note on the treatment of acoustic tumours. Acta Chir Scand 1971;137:763–5.
11. Çağıran SK, Turna M, Adatepe F, Çelik SE. Vestibular schwannoma’da stereotaktik radyocerrahi: Olgu sunumu. Okmeydanı Tıp Derg [Article in Turkish] 2013;29:14–6.
12. Bakkouri WE, Kania RE, Guichard JP, Lot G, Herman P, Huy PT. Conservative management of 386 cases of unilateral vestibular schwannoma: Tumor growth and consequences for treatment. J Neurosurg 2009;110:662–9. [CrossRef]
13. Samii M, Matthies C. Management of 1000 vestibular schwannomas (acoustic neuromas): Surgical management and results with an emphasis on complications and how to avoid them. Neurosurgery 1997;40:11–23. [CrossRef]
14. Sluyter S, Graamans K, Tulleken CA, Van Veelen CW. Analysis of the results obtained in 120 patients with large acoustic neuromas surgically treated via the translabyrinthine-transtentorial approach. J Neurosurg 2001;94:61–6. [CrossRef]
15. Wiegand DA, Fickel V. Acoustic neuroma--the patient's perspective: Subjective assessment of symptoms, diagnosis, therapy, and outcome in 541 patients. Laryngoscope 1989;99:179–87. [CrossRef]
16. Theodosopoulos PV, Pensak ML. Contemporary management of acoustic neuromas. Laryngoscope 2011;121:1133–7. [CrossRef]
17. Darrouzet V, Martel J, Enée V, Bébéar JP, Guérin J. Vestibular schwannoma surgery outcomes: Our multidisciplinary experience in 400 cases over 17 years. Laryngoscope 2004;114:681–8.
18. Samii M, Matthies C. Management of 1000 vestibular schwannomas (acoustic neuromas): The facial nerve--preservation and restitution of function. Neurosurgery 1997;40:684–95. [CrossRef]
19. Anderson DE, Leonetti J, Wind JJ, Cribari D, Fahey K. Resection of large vestibular schwannomas: Facial nerve preservation in the context of surgical approach and patient-assessed outcome. J Neurosurg 2005;102:643–9. [CrossRef]
20. Charalampakis S, Koutsimpelas D, Gouveris H, Mann W. Post-operative complications after removal of sporadic vestibular schwannoma via retrosigmoid-suboccipital approach: Current diagnosis and management. Eur Arch Otorhinolaryngol 2011;268:653–60. [CrossRef]
21. Ryzenman JM, Pensak ML, Tew JM Jr. Headache: A quality of life analysis in a cohort of 1,657 patients undergoing acoustic neuroma surgery, results from the acoustic neuroma association. Laryngoscope 2005;115:703–11. [CrossRef]
22. Schankin CJ, Gall C, Straube A. Headache syndromes after acoustic neuroma surgery and their implications for quality of life. Cephalalgia 2009;29:760–71. [CrossRef]
23. Ünsal M. Sağlık bakanlığı Okmeydanı eğitim ve araştırma hastanesi onkoloji kliniği tarihçesi. Okmeydanı Tıp Derg [Article in Turkish] 2013;29:1–2.
24. Wolbers JG, Dallenga AH, Mendez Romero A, van Linge A. What intervention is best practice for vestibular schwannomas? A systematic review of controlled studies. BMJ Open 2013;3:e001345. [CrossRef]
25. Iwai Y, Yamanaka K, Ishiguro T. Surgery combined with radiosurgery of large acoustic neuromas. Surg Neurol 2003;59:283–91.
26. Fuentes S, Arkha Y, Pech-Gourg G, Grisoli F, Dufour H, Régis J. Management of large vestibular schwannomas by combined surgical resection and gamma knife radiosurgery. Prog Neurol Surg 2008;21:79–82. [CrossRef]