OUTCOMES AFTER TREATMENT OF VESTIBULAR SCHWANNOMA BY 2 DIFFERENT MODALITIES; MICROSURGICAL AND RADIOSURGICAL TECHNIQUES

Ayman A. El Shazly MD, Mohammed A. El Wardany MD, Hatem A. sabry MD
Department of Neurosurgery, Ain Shams University, Cairo, Egypt

ABSTRACT

Background The choice between microsurgery and radiosurgery for treatment of vestibular schwannoma (VS) is debatable. There are a lot of treatment schedules, but the widely accepted is to treat tumors larger than 2.5 cm surgically, while tumors less than 2.5 cm could be offered the radiosurgical treatment. The aim of this work was to assess efficacy and safety of surgery and radiosurgery in treatment of vestibular schwannoma.

Methods The study was performed as a retrospective evaluation of 70 patients who had undergone vestibular schwannoma treatment during the period between June 2004 and June 2010. Patients with follow up less than one year and those subjected to previous vestibular schwannoma treatment were excluded from the study. The patients were classified into two groups; surgery group included 20 patients and radiosurgery groups included 50 patients. Patient records, treatment reports, and follow-up data were analyzed. The main outcome measures were magnetic resonance imaging, neurological status, patient complaints, and complications.

Results In the surgery group total or near total tumor removal was achieved in 85% of patients and tumor recurrence after surgery occurred in 1 patient (5%) (tumor control rate was 95%). Preservation of useful hearing was achieved in 30.8% of patients. Facial nerve was anatomically preserved in 85% of patients, and functional preservation (House – Brackmann grade I or II) was achieved in 75% of patients at the last follow up after surgery. Class T3b tumors showed the best results, with hearing preservation rate of 75% and functional facial nerve preservation rate of 83.3%. In the radiosurgery group tumor control rate was 98%. Hearing preservation rate was 57.1%, however facial nerve preservation rate was 98%. Results of Class T3b tumors were 50% and 80% for hearing and facial nerve preservation rate respectively.

Conclusions Tumor control rate after total or near total removal of vestibular schwannoma was comparable to control rate after radiosurgery. Although hearing and facial nerve preservation were better in the radiosurgery group, the results of Class T3b tumors after surgery were comparable to those after radiosurgery.

Keywords Acoustic neuroma; Cerebellopontine angle; Gamma knife; Radiosurgery; Vestibular schwannoma

INTRODUCTION

Vestibular schwannomas (VSs) represent 70 - 80% of cerebellopontine angle (CPA) tumors. They are benign tumors originating from Schwann cells of the vestibular nerves (more commonly the inferior vestibular nerve) [1, 2]. Three treatment options can be offered to vestibular schwannoma patients, whether conservative management with clinical and radiological observation, microsurgical tumor removal or radiosurgical treatment. Conservative management, with repeated MRI every six months, may be an option for a selected groups of patients especially those with small tumors and poor general health [3]. The large tumor size at diagnosis and the presence of cystic component do not support the role of radiosurgery as a therapeutic option [4]. The choice between microsurgery and radiosurgery for treatment of VS less than 3 cm is still controversial as there is no class 1 evidence till date to recommend one modality over the other [5-8]. Patients are advised of the treatment modalities and the choice is made together with the medical team [9]. Important information regarding outcome of both treatment options can be known from case series published in the literature from various centers around the world. Tumor control, facial nerve preservation, preservation of serviceable hearing, improvement of patient symptoms, and avoidance of treatment-related complications are the main important informations that both the physician and the patient should know before taking the decision.

The aim of this work is to evaluate efficacy and safety of surgery and radiosurgery as different treatment modalities for vestibular schwannoma.

PATIENTS AND METHODS

The study is a retrospective study conducted upon 70 patients with vestibular schwannoma treated during the period between June 2004 and June 2010.

The study represents a descriptive study of two groups of patients; surgery group including 20 patients and radiosurgery group including 50 patients. Generally, tumors larger than 2.5 cm in the greatest medial to lateral diameter or cystic tumors were treated surgically, while cases referred to radiosurgery were solid small or medium sized tumor (less than 2.5 cm in the greatest medial to lateral diameter) or poor surgical candidates.

The following patients were excluded from the study:

1- Previously treated patients; whether surgical or radiological treatment.

2- Patients lost during follow-up, and patients with follow up less than one year.

Patient records, treatment reports, follow-up data, and neuroradiological findings were analyzed. Before and after treatment, all patients were thoroughly evaluated both clinically and neuroradiologically; conducted studies included MR imaging with and without contrast enhancement, audiometry, speech discrimination tests, and auditory evoked potentials recordings. The main outcome measures were MR imaging results, neurological status, symptoms, and complications. Hannover tumor extension classification system [10] was applied. Facial nerve function was assessed using the House–Brackmann grading system [11]. Hearing was graded according to Gardner Robertson grading system [12].

Surgery was performed in Ain Shams university hospitals, Cairo, Egypt and the retrosigmoid suboccipital approach was the corridor of surgery in park-bench or semisitting position. Extent of tumor removal was classified as:

- Total: All of the tumor material was removed without any remnants in post operative contrasted MRI brain.
- Near-total: a thin layer of tumor attached to one or more nerves was intentionally left behind.
- Subtotal: imaging studies revealed gross evidence of residual disease, which is less than 50% of the initial tumor.

Radiosurgery was performed using Leksell gamma unit (model C; Elekta Instruments, Stockholm, Sweden) in the Gamma Knife Center located in Nasser Institute, Cairo, Egypt and MRI was used for treatment planning in all cases. The marginal dose used in all patients was 12 Gy to the 50% isodose line, with maximum dose of 24 Gy. Tumor control based on MRI brain with Gadolinium was classified as following:

- Tumor shrinkage was defined as decrease of tumor volume by more than 10% of the initial tumor volume.
- Tumor expansion: if there was increase in tumor volume by more than 10% of the initial tumor volume.
- Stabilized tumor: if the tumor volume was increased or decreased less than 10% of the initial tumor volume.

RESULTS

From June 2004 to June 2010, 70 patients with vestibular schwannoma were treated, 20 of them were operated and 50 were treated by Gamma Knife radiosurgery. The mean age in the surgery group was 43 years (range, 27-76 years) and in the radiosurgery group was 50.56 years (range, 21-67 years).

All irradiated tumors were smaller than 25 mm (in the largest medial to lateral diameter measured through axial MRI), however all operated patients had tumors larger than 25 mm except 3 patients who had cystic tumors (Figure 1).

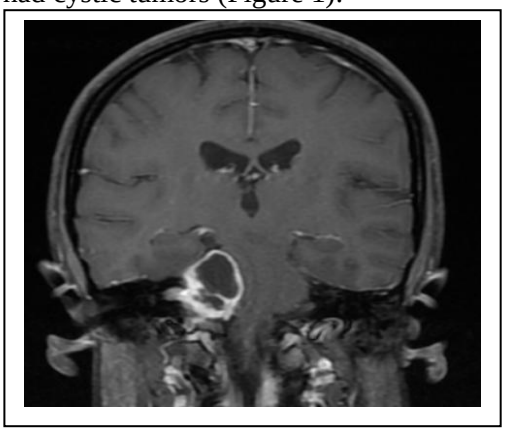

Figure 1 MRI brain T1WI with Gadolinium, showing large single cystic tumor surrounded by a relatively small amount of peripheral tissue.

The tumor size and tumor extension in the surgical and radiosurgery groups are presented in Table 1 A, B.

Table 1 Tumor size and tumor extension in the surgical group (A) and radiosurgery group (B)

(A)

Hannover Classification of Tumor Extension	Tumor Size			
	medium size (11-25 mm)	large size (25-40 mm)	extra large (> 40 mm)	**Total**
T3b	3	3	0	6
T4a	0	10	1	11
T4b	0	2	1	3
Total	3	15	2	20

(B)

Hannover Classification of Tumor Extension	Tumor Size		
	small size (<10 mm)	medium size (11-25 mm)	**Total**
T1	8	0	8
T2	17	0	17
T3a	0	20	20
T3b	0	5	5
Total	25	25	50

Tumor control

In the surgery group, total tumor removal was achieved in 15 patients (75%), near total (thin layer of tumor left) in 2 patients (10%), while in 3 patients (15%) tumor was removed subtotally (residual less than 50%) to preserve neurological function. Mean follow up period of 25.8 months (range, 18 to 42 months). Tumor recurrence was detected in only one patient (5%), who developed increase in residual tumor size and radiosurgery was performed for this patient (tumor control rate was 95%). All Class T3b tumors were totally removed and no recurrence was detected (Table 2).

Table 2 Tumor control at the last follow up in relation to tumor extension in the surgery group.

Hannover Classification of Tumor Extension	Extent of tumor removal			
	Total	Near total	Subtotal	**Total**
T3b	6	0	0	6
T4a	8	2	1	11
T4b	1	0	2	3
Total	15	2	3	20

In the radiosurgery group, early tumor shrinkage within the first 6 months occurred in 4 patients (8%), and then the tumor continued to decrease in size during further follow-up images in all these patients. Transient tumor expansion after treatment occurred in 2 patients (4%), this expansion occurred at some stage between the 6^{th} and 12^{th} month after treatment, these tumors eventually decreased in size from their maximum peaks at 12-24 months after the initial expansion. At last follow up, 21 patients had tumors with the same size as pretreatment size, 28 patients have had a shrunken tumor size and one patient suffered obvious tumor enlargement (re-growth) after an arrest seen during the 6 months and 12 months follow up, so the magnetic resonance imaging tumor control was 98% (Table 3). Forty-nine patients required no additional treatment after Gamma Knife radiosurgery, so the clinical tumor

control at the last follow up was 98%. The follow up period ranged from 18 to 43 months, with an average of 30.5 months.

Tumor expansion by more than 10% of the initial volume at the last follow up occurred in one patient (2%). This patient had class T3b tumor. It was found that this failure of tumor control was significantly correlated to tumor extension (according to Hannover Classification), with P-value 0.04 (Table 4).

Table 3 Tumor control at 6 months, 18 months after treatment and at the last follow up in the radiosurgery group.

Time of follow-up	Shrinkage	Stable	expansion
At 6 months	4	44	2
At 12 months	14	36	0
At last follow up	28	21	1

Table 4 Tumor control at the last follow up in relation to tumor extension in the radiosurgery group.

Hannover Classification of Tumor Extension		last follow-up			
		shrinkage	stable	expansion	**Total**
	T1	8	0	0	8
	T2	15	2	0	17
	T3a	4	16	0	20
	T3b	1	3	1	5
Total		28	21	1	50

Hearing preservation

In the surgery group, preoperative hearing was serviceable (Gardner Robertson Grade I or II) in 13 patients (65%). Of these 13 patients, 4 patients (30.8%) had preservation of useful hearing postoperatively. The best hearing preservation rate was in Class T3b tumors (75%, 3 out of 4 patients), followed by Class T4a tumors (12.5%, 1 out of 8 patients); however in Class T4b tumors, hearing preservation rate was 0% (0 out of 1 patient) (Table 5 A). In the cases with preoperative serviceable hearing, a significant positive correlation was found between postoperative hearing grade and tumor extension (P-value 0.035).

In the radiosurgery group, hearing was serviceable (Gardner-Robertson grade I and II) in 14 patients (28%) before treatment. Of these 14 patients, post-treatment useful hearing (Gardner-Robertson grade I and II) was preserved in 8 patients (57.1%). The best hearing preservation rate was in Class T1 tumors (100%, 2 out of 2 patients); followed by Class T3a tumors (66.7%, 2 out of 3 patients); followed by Class T3b tumors (50%, 1 out of 2 patients), however in Class T2 tumors, hearing preservation rate was the least successful (42.9%, 3 out of 7 tumors) (Table 5 B). In cases with pre-treatment serviceable hearing, no factor (tumor extension, tumor volume, or early tumor expansion) was found to significantly affect hearing preservation.

Table 5 Preoperative and postoperative hearing level in relation to tumor extension in surgery group (A) and radiosurgery group (B).

(A)

Hannover Classification of Tumor Extension		Preoperative Gardner-Robertson Hearing Grade					Postoperative Gardner-Robertson Hearing Grade				
		I	II	III	IV	V	I	II	III	IV	V
	T3b	1	3	1	0	1	1	2	1	0	2
	T4a	0	8	1	0	2	0	1	1	1	8
	T4b	0	1	0	0	2	0	0	0	0	3
Total		1	12	2	0	5	1	3	2	1	13

(B)

Hannover Classification of Tumor Extension		Pre-treatment Gardner-Robertson Hearing Grade					Post-treatment Gardner-Robertson Hearing Grade				
		I	II	III	IV	V	I	II	III	IV	V
	T1	0	2	2	1	3	0	2	0	2	4
	T2	1	6	3	6	1	0	3	2	10	2
	T3a	2	1	6	4	7	1	1	0	9	9
	T3b	1	1	0	1	2	1	0	2	0	2
Total		4	10	11	12	13	2	6	4	21	17

Facial nerve preservation

In the surgery group, 17 patients had House-Brackmann (HB) grade I facial function preoperatively, while the other 3 patients had HB grade II facial function. Postoperatively, facial nerve was anatomically preserved in 17 patients (85%); however it was not preserved in 3 patients. Immediately after surgery facial nerve function was deteriorated in most of the patients, with only 7 patients (35%) had HB grade I or II facial function. This deterioration of facial function was transient in most of the patients, so that 3 months after surgery, 14 patients (70%) had HB grade I or II facial function, 1 patient had HB grade III facial function, 2 patients had HB grade IV facial function, however only 3 patients (in whom the facial nerve was not anatomically preserved) had HB grade VI facial function. Even after 3 months improvement continued in some patients, so that at the last follow up only 3 patients had HB grade VI facial function, 2 patients had HB grade III facial function, and 15 patients (75%) had HB grade I or II facial function. The functional results were better in patients with Class T3b tumors, in whom functional preservation of facial nerve function (HB grade I or II) was achieved in 67.66% (4 out of 6 patients) before discharge from the hospital (P value 0.03) and in 83.33% (5 out of 6 patients) at the last follow up (insignificant, P value 0.187). A strong positive correlation was found between tumor size and postoperative facial nerve function before discharge, and at the last follow up, with P-value 0.003, and 0.025 respectively (Table 6).

In the radiosurgery group, 48 patients had HB grade I facial function before treatment, while only two patients had HB grade II facial function (both of them had class T3b tumors). After treatment, only two patients developed deterioration in facial nerve function, these two patients had class T3b tumors, one patient was deteriorated from HB grade I to HB grade II facial function, while the other patient was deteriorated from HB grade II to HB grade III facial function. The functional preservation of facial nerve function (HB grade I or II) in the radiosurgery group was achieved in 98% (49 out of 50 patients), however in Class T3b tumors the rate of functional facial nerve preservation was 80% (4 out of 5 patients). Facial nerve function results were found to be significantly correlated to tumor extension (P value 0.046) (Table 7).

Table 6 Postoperative facial nerve function in relation to tumor extension in surgery group.

Hannover Classification of Tumor Extension		House-Brackmann grade (before discharge)						Total	House-Brackmann grade (last follow-up)						Total
		I	II	III	IV	V	VI		I	II	III	IV	V	VI	
	T3b	4	0	0	1	1	0	6	4	1	1	0	0	0	6
	T4a	0	3	5	0	2	1	11	6	3	1	0	0	1	11
	T4b	0	0	1	0	0	2	3	1	0	0	0	0	2	3
Total		4	3	6	1	3	3	20	11	4	2	0	0	3	20

Table 7 Pre- and post-radiosurgery facial nerve function according to House-Brackmann grading.

	House-Brackmann grade				
	I	II	III	IV	V
Before treatment	48	2	0	0	0
At last follow up	47	2	1	0	0

Other symptoms and complications

In the surgery group, complications were in the form of: hemiparesis (1 patient), transient CSF rhinorrhea (1 patient), postoperative hematoma (2 patients), hydrocephalus (1 patient), ventriculoperitoneal shunt infection (1 patient), and occipital neuroma (1 patient). Seven patients (17.5%) had presented with preoperative trigeminal nerve dysfunction and all of them improved completely within the first year after surgery. Thirteen Patients presented with preoperative vertigo, all of them improved completely within the first 3 months after surgery except one patient who improved partially after surgery. One patient developed vertigo after surgery without having the symptom preoperative.

In the radiosurgery group, two patients presented with trigeminal nerve dysfunction before treatment, one of them improved completely, while the symptoms became less severe after treatment in the other patient. One patient developed permanent facial dysthesia 6 months after treatment. Two patients developed transient facial spasm after radiosurgery that improved after 9 to 18 months. Eleven patients had vertigo before treatment, vertigo improved in 4 of them after treatment, and it became the same as before treatment in other 5 patients, while it was increased in severity in 2 patients after treatment. Two patients developed new vertigo, without having the symptom before treatment.

DISCUSSION

Excellent tumor control rate after surgical removal of vestibular schwannoma (VS) can be achieved after total and near total removal; however the control rate is less after subtotal removal [13, 14]. In this work, no recurrence was detected in totally and near totally removed tumors, however one patient (5%) developed tumor recurrence after subtotal removal.

In their meta-analysis of articles considering tumor control after radiosurgery for VS, Pannullo, et al [15] found that the rate of stabilized disease (tumors that decreased in size or remained stable) was 92.2%. In this work, the rate of tumor control after radiosurgery was 98%, and the rate of failed treatment was found to be significantly related to tumor extension (P-value 0.04).

The definition of tumor recurrence and failed treatment after radiosurgery varied widely in the literature [16-18], at the same time the results of surgery after failed radiosurgery of VS is relatively poor especially regarding the cranial nerve outcomes [19] .

Hearing preservation after VS surgery is affected dramatically by both tumor size and preoperative hearing quality [20, 21]. We found that tumor extension significantly affected postoperative hearing grade in patients with preoperative serviceable hearing (P-value 0.035). Although the rate of hearing preservation after surgery (30.8%) is less than that after radiosurgery (57.1%), but in Class T3b tumors the rate of hearing preservation was higher after surgery (75% after surgery versus 50% after radiosurgery).

It was documented that hearing preservation after radiosurgery for VS is not significantly affected by tumor size [22], but delayed hearing loss can occur

after Gamma Knife radiosurgery especially in patients who developed early deterioration of hearing [23].

Facial nerve preservation represents a great challenge in microsurgical treatment of VS, However, the introduction of routine intraoperative facial nerve monitoring increases the rates of facial nerve preservation [24-27]. Also, radiosurgery may endanger the facial nerve, with a documented permanent facial neuropathy rate between 4% and 19% [28].

Many authors reported that tumor size is the main predictor of facial nerve preservation after surgery for VS [29-33]. However, tumor volume less than 1.5 cm^3 and radiation dose less than 13 Gy were reported as important prognostic factors that significantly affected facial nerve preservation after radiosurgery for VS [34]. Tumor extension significantly affected the results of facial nerve function after surgery and radiosurgery in this work, with results after surgery for Class T3b tumors comparable to those after radiosurgery.

The complications developed after surgery in this work were transient and did not lead to a permanent morbidity, apart from 3 patients with complete facial palsy. The patient with postoperative hemiparesis had motor power grade 4 after surgery and improved to grade 5 two years after surgery. The same for radiosurgery group, all complications were transient apart from the patient with facial dysthesia.

The results in this work showed that patients having vertigo before treatment usually improved after surgery, but after radiosurgery the symptoms usually remain or even become more severe symptoms. Many authors reported that patients presented with imbalance do poorly with radiation treatment and are better served with surgical intervention and the nerve section included with it [9, 16, 35, 36].

CONCLUSION

Tumor control rate after total or near total removal of vestibular schwannoma was comparable to control rate after radiosurgery. Although hearing and facial nerve preservation were better in the radiosurgery group, the results of Class T3b tumors after surgery were comparable to those after radiosurgery.

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النتائج بعد علاج الورم الشفاني الدهليزي بطريقتين مختلفتين؛ الجراحة المجهرية والجراحة الأشعاعية

الملخص

الخلفية: الاختيار بين الجراحة المجهرية والجراحة الإشعاعية لعلاج الورم الشفاني الدهليزي قابل للنقاش. هناك الكثير من جداول العلاج، ولكن هناك قبول واسع لعلاج الأورام الأكبر من 2.5 سم بأستخدام الجراحة المجهرية، في حين يمكن تقديم الأورام أقل من 2.5 سم للعلاج بأستخدام الجراحة الأشعاعية. الهدف من هذا العمل هو تقييم فعالية وسلامة الجراحة المجهرية. والجراحة الأشعاعية فى علاج الورم الشفانى الدهليزى.

الطرق: أجريت الدراسة على أنها تقييم بأثر رجعي ل 70 من المرضى الذين خضعوا للعلاج من الورم الشفاني الدهليزي خلال الفترة ما بين يونيو 2004 ويونيو 2010. تم استبعاد المرضى الذين يعانون من متابعة أقل من سنة واحدة أوالذين قد خضعوا لعلاج الورم الشفاني الدهليزي من قبل من هذه الدراسة. تم تصنيف المرضى إلى مجموعتين، مجموعة الجراحة المجهرية وشملت 20 مريضا ومجموعة الجراحة الأشعاعية وشملت 50 مريضا. وقد تم تحليل سجلات المرضى، وتقارير العلاج، وبيانات المتابعة. وكانت القياسات الرئيسية للنتائج هى صور الرنين المغناطيسي، والحالة العصبية للمرضى، وشكاوى
المرضى، والمضاعفات

النتائج: في مجموعة الجراحة المجهرية تم إزالة الورم الكلياً أو بالقرب من الكلي في 85٪ من المرضى وقد عاد الورم بعد الجراحة مرة أخرى فى مريض واحد (5٪) لذلك فأن معدل السيطرة على الورم كان 95٪. وقد تحقق الحفاظ على السمع مفيداً في 30.8٪ من المرضى. وقد تم الحفاظ تشريحيا على العصب الوجهي في 85٪ من المرضى، والحفاظ علي وظيفته في 75٪ من المرضى في نهاية المتابعة. وأظهرت فئة الأورام T3B (فى تقسيم هانوفر) على أفضل النتائج، وكان معدل الحفاظ على السمع 75٪ ومعدل الحفاظ على وظيفة العصب الوجهي 83.3٪. في مجموعة الجراحة الأشعاعية كان معدل السيطرة على الورم 98٪. وكان معدل المحافظة على السمع 57.1٪، ولكن معدل المحافظة على وظيفة العصب الوجهى كان 98٪. وكانت نتائج الأورام فئة T3B (فى تقسيم هانوفر) 50٪ و 80٪ لمعدل الحفاظ على السمع و العصب الوجهى على التوالي.

الاستنتاجات: معدل السيطرة على الورم الشفاني الدهليزي بعد إزالته كلياً أو بالقرب من الكلى بواسطة الجراحة المجهرية كان متقارب من معدل السيطرة بعد الجراحة الإشعاعية. على الرغم من أن معدل الحفاظ على السمع و وظيفة العصب الوجهى كان أفضل في مجموعة الجراحة الأشعاعية، ألا أن النتائج الأورام فئة T3B (فى تقسيم هانوفر) كانت متقاربة فى المجموعتين.