Evaluation of Stereotactic Radiosurgery for Cerebellopontine Angle (CPA) Meningioma and Schwannoma after Microsurgical Decompression

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ABSTRACT

Background: CPA tumors are the most common neoplasms in the posterior fossa. After microsurgical decompression, the residual parts of meningiomas and schwannomas can be treated with stereotactic radiosurgery. Objective: The aim of the study is to evaluate long-term follow up of stereotactic radiosurgery after microsurgical decompression. Patients and Methods: Our study included a total of 32 patients with CPA meningioma and schwannoma, 23 cases with vestibular schwannoma and 9 cases with meningioma, these patients were subjected to microsurgical decompression and then treated with GK (gamma knife) and were followed up for at least 2 years. Results: Postoperative improvement occurred in 100% of patients with headache and in 82.5% of patients with ataxia and the postoperative complications were 7th nerve palsy occurred in 62.5% of cases, 9.4% had bulbar manifestations 3.1% had 5th nerve affection (pain), 18.75% needed re-operation due to presence of residual parts and recurrence of symptoms. Post gamma knife improvement occurred in 75% of patients presented with ataxia, and in 33% of patients presented by 5th nerve affection, and improvement occurred in single case presented by head ache, single case presented by vertigo and single case presented by bulbar symptoms. Complication after gamma knife were one case of hearing deterioration, one case needed re-surgery due to tumor regrowth, edema in one case and fits in one case. Radiologically 19 cases were less in size (59%), 9 cases retained the same size (28%) and 4 cases showed progressive increase in size (13%). Conclusion: (GKS) has achieved the goals of desired treatment in both aspects: long term tumor control and lowered morbidity.

Keywords: gamma knife, cerebello-pontine-angle, SRS, skullbase, adjuvant therapy.

INTRODUCTION

Generally speaking, for patients presenting with CPA tumors, treatment options include observation with close follow-up, operative excision and radiosurgery, or a combination of these therapies. For those tumors that are suspected to be benign, observation is a reasonable option, particularly when the patient has minimal symptoms with no life threatening symptoms and acceptable presentation for life style of the patients, especially in old age patients (older than 70 years). However, while small tumors can be treated with minimal risks, larger tumors are more difficult to treat and may cause significant post-surgical problems. Because CPA tumors are deep in location and surrounded by critical structures, conventional neurosurgical approaches are disadvantageous because of the need for significant brain retraction, poor control of the lesion and adjacent structures, and often suboptimal exposure.

In 1969, the first case of vestibular schwannoma (VS) treated by (GKS) was performed by Lars Leksell at the Karolinska institute in Stockholm, Sweden. This innovative and thoughtful neurosurgeon was impressed by the high rates of morbidity and mortality that was associated with the surgical resection of VS in the fifties.

Consequently, SRS is currently the most common treatment for small to medium sized VSs, resulting in good tumor control and functional outcomes.

PATIENTS & METHODS

This is a retrospective study involving 32 patients who were subjected to microsurgery for CPA tumor in Ain Shams University followed by (GKS) in Naser Institute from June 2001 to October 2009 and were followed up for at least 2 years.

All patients were subjected to detailed medical history taking, general and neurological examination, neuroradiological assessment in the form of MRI with and without contrast and auditory investigations in the form of pure tone audiometry and Arabic speech discrimination in cases where hearing was serviceable.

All patients underwent decompression with standard retrosigmoid suboccipital approach (Janetta approach). Generally the retrosigmoid approach is a safe and reliable approach for CPA tumor decompression.

SRS Protocol: The GKS procedure was performed with the aid of the leksell model G stereotactic frame (Elekta instruments) the frame was applied after mild sedation and local anesthesia had been administered after frame application all patient underwent MRI studies, axial and coronal T1-weighted
image with contrast enhancement were used for dose planning.

All patients treatment were planned with gamma plan software version 9. The prescription dose used in the study was strictly confined to 12 Gy but with varying isodose lines from 35 to 55% with a median of 50% and a mean of 49.6%.

Post treatment Follow Up

Patient evaluation

First of all, the pretreatment symptoms were documented and compared subjectively by the patient post treatment state. This was followed by neurological examination of the patient, keeping in mind any signs detected in the first examination, and comparing them with the current state.

Post treatment Investigations

In all cases an MRI with and without contrast axial, sagittal and coronal cuts was performed. MRI was performed at 6, 12, 24 and 36 month intervals. The routine MR examinations included the following studies:

1. Volumetric assessment was done using the following geometrical formula for the volume (V) of a prolate ellipsoid based on the largest transverse (A), anteroposterior (B) and coronal diameters (C): 
   \[ V = \frac{4}{3} \times 3.14 \times A \times B \times C \]

   but tumor dimensions measured off the MRI images were not always accurate due to the fact that the MRI was not always done to the same parameters regarding the scanning angle. So, we also assessed the tumor size in relation to the surrounding structures and the mass effect of the tumor on adjacent structures especially the brain stem, cerebellum and the effect of 4th ventricle patency and in most cases there were no actual difference in assessing tumor size.

2. Detection of changes of gadolinium enhancement in the tumors.

3. Detection of adverse radiation effects or perifocal edema surrounding the tumor.

In cases in which hearing was serviceable before treatment, an audiogram with pure tone audiometry and speech discrimination was performed.

RESULTS

In our study we had 32 cases with a CPA tumor (schwannoma or meningioma), all of them subjected to Gamma Knife Radiosurgery from June 2001 to October 2009 after they were subjected to microsurgery before this treatment. All patients were followed clinically and radiologically for at least 2 years.

We had 23 (71%) cases of Vestibular Schwannomas and 9 (29%) cases of Meningiomas. No patients were discovered to have malignant tumors.

![Figure (1): Different types of pathologies in our series](image)

While Meningiomas predominate in females (8 female and one male), Schwannomas are near equally distributed in both genders (13 female and 10 males).
Pre-operative symptoms were ataxia (23 cases) and vertigo (3 cases). Headache was the main symptom of ↑ICT (23 cases), blurring of vision occurred in 9 cases, vomiting was present in 2 cases. 5 cases of them had a VP shunt pre-operatively. Deafness was present in 27 cases (only 5 patients were having useful hearing), trigeminal pain in 4 patients, bulbar symptoms in one case and blindness was present in one case due to ↑ICT.

Post-operatively approximately, all cases with ↑ICT improved, regarding cases with ataxia 19 cases (82.5%) improved, 3 cases had moderate improvement, one case only did not improved. The 3 cases with vertigo improved. 75% of cases with trigeminal pain improved. The only case with bulbar symptoms improved.
The hallmark of post-operative complications was 7th nerve palsy (62.5%: 19 paralysis & 1 case palsy), 2 of them performed hypoglossal-facial anastomosis. 9.4% had bulbar manifestations. 3.1% suffered 5th nerve affection (pain). 18.75% needed reoperation due to incomplete resection of the tumor and recurrence of symptoms, 9.4% needed VP shunts. Other less frequent complications were tremors (1 case), nystagmus (1 case), Cerebellar speech (1 case), intra-tumoral bleeding (1 case) and hemiparesis (1 case).

![Figure 5: Post-operative complications](image)

Regarding degree of surgical removal, we graded decompression to 3 grades. Minimal decompression (removal of less than 1/3 of the tumor). Moderate decompression (removal of between 1/3 and 2/3 of the tumor). Subtotal decompression (removal of more than 2/3 of the tumor). Minimal decompression was done in 50% of cases. Moderate decompression was done in 22% of cases. Subtotal decompression was done in 28% of cases.

![Figure 6: Volume of the tumor removed surgically](image)

Before Gamma Knife treatment, main symptoms were 7th nerve paralysis (19 cases), 5th nerve palsy (3 cases), ataxia (4 cases), bulbar symptoms (1 case), headache (1 case), vertigo (1 case) and there were 27 deaf (Non-Functioning ears) cases.

![Figure 7: Main symptoms before Gamma Knife Treatment](image)

Improvement after gamma knife treatment was as follow, 75% of patients with ataxia improved and 33% of patients with 5th nerve affection improved, and also improvement occur in a single case presented by headache, single case presented by vertigo and single case presented by bulbar symptoms. No facial deterioration recorded after gamma knife treatment.
Complications after Gamma Knife treatment included: one case of hearing deterioration (SRT decreased from 30 db to 55 db in 3 years). Re-surgery & VP shunting (1 case: VP shunt inserted after 2 years from the treatment as the tumor increased in size. Decompression done after 30 months, Pathology showed no malignancy), edema (1 case), this edema resolved by steroid, fits (1 case) was controlled by medical treatment.

Radiologically, 19 cases were less in size, 9 cases retained the same size & 4 cases (13%) showed progressive increase in size.

Mean duration between Gamma Knife Treatment and failure was 24 months. 3 of the 4 cases had only radiological failure. Only one case (25%) had symptoms: persistent ataxia then, she developed hydrocephalus and VP shunt inserted then, re-operation done before Re-Treatment. No cases were proved to have malignancy. All failed cases had Gamma Knife Treatment with mean duration of follow up 6 months.

Illustrated cases

Figure (10): all T1WI post contrast; 50 years old female was complaining of occasional headache, complete left side hearing loss, blurring of vision and ataxia. VP shunt inserted. Her large left vestibular schwannoma was sub-totally removed. This 1.1 cc tumor received 12 Gy to the 40% isodense with 92% and a conformity index of 1.24. Follow up after 6 years tumor size is smaller.
Figure (11): All T1WI post contrast; a 40 years old male complained of left sided complete hearing loss and headache. His left vestibular schwannoma was decompressed. He suffered from moderate facial palsy (improved by time), dry left eye. This 4.4 cc tumor received 12 Gy to the 50% isodense with 90% cover and a conformity index of 1.1. After 5 years, tumor size reduced with loss of central enhancement, with no clinical deterioration.

DISCUSSION

Our study included 32 cases with a CPA tumor (schwannoma and meningioma), all of them subjected to Gamma Knife Radiosurgery from June 2001 to October 2009 after they were subjected to microsurgery before this treatment.

No cases other than schwannoma and meningioma were treated in our study. More than two thirds of the patients had schwannomas. This agrees with the well-known prevalence of the vestibular schwannoma in this particular anatomical location, followed by the meningioma. The female to male ratio in vestibular schwannoma cases was 1.3:1. It nearly agrees with the known gender distribution ratio of vestibular schwannoma of 1:1. Female gender was dominating in meningioma cases (9:1 female to male). This agrees with the well-known domination of this tumor in females.

Mean age at presentation in Meningioma in our study was 41 years ranging from 25 to 50 years. This agrees with the fact of frequency of meningioma in middle age and has the highest incidence in the fifth decade. Mean age at presentation in Schwannomas in our study was 39 years ranging from 20 to 70 years which agrees with range of age in other studies.

Before Gamma Knife treatment, main symptoms were 7th nerve paralysis (20 cases), 5th nerve palsy (3 cases), ataxia (4 cases), bulbar symptoms (1 case), headache (1 case), and vertigo (1 case) and there were 27 deaf (5 Functioning ears) cases.

The prescription dose used in the study was strictly confined to 12 Gy, but with varying isodose lines, from 35 to 55% with a median of 50% and a mean of 49.6%. In Gamma knife radiosurgery a dose of 11–13 Gy is typically prescribed to the 50% isodose line that conforms to the tumor margin. Dose prescription for vestibular schwannomas has changed significantly over the past 10 years. A margin dose of 12–13 Gy is associated with a low complication rate and yet maintains a high rate of tumor control.

Risk factors for cranial nerve damage during radiosurgery are reported to be total dose, total volume, prior resection, length of cranial nerve irradiated, and the maximal dose to brain stem. However, recently 14 Gy was applied to small sized tumors, 12 Gy to medium sized tumors, and 10 Gy to large one. Now the trend is to decrease the dose to 12 Gy for small sized tumors. Despite the decreased irradiation of 12 Gy, the tumor growth suppression rate is same as before, and the complications of irradiation for auditory and facial nerves have decreased. Although proper dose selection was not established, it must not exceed 14 Gy for CPA radiosurgery. In our study, the treatment planning was done using high resolution with thin slices and gadolinium enhancement with 3-D reconstruction for the treatment planning. For the follow up, MR imaging with gadolinium enhancement was used. Post GKS follow up in this study revealed a hearing preservation rate of 80%, as 4 out of 5 patients maintained functional hearing after 2 years of treatment.

Hearing preservation is not correlated to the maximal radiation dose at the tumor but only to the
maximal dose at the cochlea. The purpose of developing GKRS techniques was to avoid collateral damage in healthy tissues. 15

The hearing preservation rate achieved after the introduction of MRI guided dose planning was raised to 67% of the patients who had serviceable hearing before undergoing GKS. The hearing preservation rate after radiosurgery for CPA has been reported to be in the range of 40 to 78.6%. It is not easy to simply compare the various reports on global hearing preservation because of the lack of uniformity in reporting results. Hempel et al. have carried out GKS on 123 patients since 1994, and achieved a tumor control rate of 96.7%; the mean impairment of hearing was 18% for 8.2 years after GKS. Hasegawa et al. conducted a follow-up observation for a relatively long term of 135 months, applied the mean marginal dose of 14.6 Gy, and hearing preservation rate was 37%. This data was relatively lower than other previous reports. 8

In our study, improvement after Gamma Knife treatment was 100% of headache cases, 75% of ataxia cases, 100% in vertigo, 33% in 5th nerve affection and 100% in bulbar symptoms.

Complications after Gamma Knife treatment included: one case of hearing deterioration (SRT decreased from 30 db to 55 db in 3 years). Re-surgery & VP shunting (1 case: VP shunt inserted after 2 years after treatment as the tumor progressed. Decompression was done after 30 months, Pathology showed no malignancy, edema (1 case), fits (1 case). No reported cases of facial nerve deterioration after gamma knife treatment.

Kondziolka et al. in 1998 reported normal facial function was preserved in 79% of the 155 patients in his study. He also reported that no patient who had a normal facial function suffered from complete facial palsy after GKS. Only some of the patients with a pre-existing deficit (grades III-V) due to previous surgical trauma to the nerve have suffered progress to complete grade VI palsy.

Radiologically, 19 (59%) cases reduced in size, 9 (28%) cases attained the same size & 4 cases (13%) increased in size by about (20%). Most of failed cases are essentially large tumors to treatment. Mean duration between Gamma Knife Treatment and failure was 24 months. 3 of the 4 cases had only radiological failure. Only one case (25% of failed cases) had symptoms: persistent ataxia then, she developed hydrocephalus and VP shunt inserted then, re-operation done before Re-Treatment. No cases were proved to have malignancy.

According to the results of GKS for CPA tumors reported by many gamma knife centers, tumor control rate ranges from 87 to 98%. 5,13,10,13,19

Treatment of large tumors remains a challenge to neurosurgeons regardless of whether they perform microsurgery or radiosurgery. The size of the tumor is critical to efficacy and safety. In a large series, a poor control rate was identified in large tumors compared to small tumors 5. In general, gamma knife radiosurgery is not a suitable treatment modality for large tumors (mean diameter greater than 3 cm) because a large tumor size increase the risk of complications compared to small tumors. Significant peri-tumoral edema invariably occurs after gamma knife treatment for large tumor (larger than 3 cm), this edema potentially cause aggravation of symptoms and clinical deterioration. To avoid these complications, a low prescribed dose is recommended for large tumors. However low marginal doses have been associated with increased rate of tumor recurrence. In our study we found that the tumor size is very important in the success or failure of the treatment with gamma knife. Large tumor showed failure in treatment more than smaller one, the failed cases in our study were essentially large tumors to treatment regarding tumor nature cystic vs solid type we prefer microsurgery to radiosurgery for the treatment of cystic tumors because of a risk of rapid cyst expansion after radiosurgery. We found no significant difference in response to treatment between schwannoma and meningioma.

CONCLUSION

We recommend gamma knife radiosurgery as a planned “treatment” after microsurgery. The additional radiosurgical boost is delivered accurately to the smaller region of the tumor that shows contrast enhancement on T1-weighted contrast-enhanced MR imaging scans. Radiosurgery is certainly not a cure for brain tumors, but it does offer an adjunctive form of treatment that is clinically effective, safe, and cost effective. The simplicity of the treatment, the fact that it interferes very little with normal life activities, and the virtual lack of peri-operative complications make gamma knife radiosurgery attractive to both patients and referring physicians.

REFERENCES


