International Journal of Pharmaceutical and Bio-Medical Science

ISSN(print): 2767-827X, ISSN(online): 2767-830X

Volume 04 Issue 10 October 2024

Page No: 776-788

DOI: https://doi.org/10.47191/ijpbms/v4-i10-02, Impact Factor: 7.792

Safety and Efficacy of Multisession Gamma Knife Radiosurgery for (Large Benign Intracranial Lesions > 3cm)

Sarah Zuhair kurdi[1], Yasir Mohammed Hasan Hamandi[2]

[1]M.B.Ch.B, F.I.C.M (neurosurgery), Lecturer/neurosurgeon at Al- Kufa university-college of medicine, Al-Sader medical city, Najaf, Iraq

[2]M.B.Ch.B/F.I.C.M.S (neurosurgery), Professor/consultant Neurosurgeon, Gamma knife department at Saad Al wittry Neuroscience Hospital & Al-Nahrain university-college of medicine, Baghdad, Iraq

ABSTRACT

Background: Stereotactic radiosurgery is delivery of an ablative dose of ionizing radiation to a focused target with 3D localization to elicit a specific radiobiological response and sparing the surrounding normal brain tissue.

Objective: to evaluate safety and efficacy of Gamma knife radiosurgery by volume staging of large benign intracranial lesions.

Patients and methods: prospective cohort study is conducted at Saad Alwitry neuroscience hospital, gamma knife department between June 2017 to February 2021, 60 patients (25 case meningioma,15 case vestibular schwannoma ,10 case arteriovenous malformation and 10 patients with pituitary macro-adenoma) having large lesions of >3cm were treated by multisession radiosurgery (2-3 sessions), time between sessions (24hr-6m), follow up time ranged from(6ms-3yr).

Results: rate of growth control for meningioma, vestibular schawannoma, AVM and pituitary macro-adenoma was 76 %,53.3% ,30% and 60% while reduction in lesion size is 20%, 33.3%, 70% and 30% respectively and clinical improvement was 86.4% for meningioma ,52.6% for VS ,73.2% for AVM and 88% for PA and the complications reported were 15.2%.

Conclusion: volume staged multisession GKSR is effective, safe and well tolerated with low morbidity modality for these large lesions.

KEYWORDS: Gamma knife , stereotactic radiosurgery ,multisession , gray ,volume staged.

ARTICLE DETAILS

Published On:
04 October 2024

Available on:
https://ijpbms.com/

INTRODUCTION

Stereotactic radiosurgery is a distinct discipline that utilizes externally generated ionizing radiation in certain cases to inactivate or eradicate (a)defined target(s) in the head and spine without the need to make an incision. The target is defined by high resolution stereotactic imaging. it is performed in a single session, using a rigidly attached stereotactic guiding device, other immobilization technology and/or a stereotactic image-guidance system, but can be performed in a limited number of sessions, up to a maximum of five. Technologies that are used to perform stereotactic radiosurgery include linear accelerators, particle beam accelerators, and multisource Cobalt 60 units. (1)

When tumor size increases >3cm or critical organ lies very close (<2 mm) to the tumor, single session SRS is usually avoided because of the higher chances of normal tissue toxicity and/or poor local controls. (2)

when tumor size increases to >3cm, surgical resection becomes an integral part of treatment. But radiation, perhaps fractionated regimen becomes more preferred treatment if surgery is not possible for any reason such as deep seated / eloquent area tumors, or critical organ is encased, invaded, or lying close to the tumor, or surgically unresectable tumor to avoid gross neurological deficit, medically inoperable (elderly patient, heart disease, uncontrolled diabetes mellitus/hypertension) or patient refuses surgery (either because of the high risk involved in surgery or patient preference. In these situation,multisession SRS becomes an appropriate non-invasive alternative primary treatment option

for this group of patients with adequate therapeutic benefits and minimum normal tissue toxicity. (3)

Multisession SRS is based upon the basic principles of radiobiology concept of fractionated radiotherapy 4 Rs stand for repair, re-assortment, repopulation and re-oxygenation. (4)

We investigated group of patients, who had large benign brain lesions (meningioma, VS ,AVM and pituitary macroadenoma) without previous surgery or they may undergo surgical resection but had residual tumors >3 cm.

We assume that multisession stereotactic radiosurgery can be used for these types of patients to reduce the normal tissue toxicity without compromising the therapeutic benefits to achieve good local controls equivalent to or superior to existing standard management strategies.

METHODS

This is a prospective cohort study conducted at Dr. Saad Alwitry Neuroscience Hospital, Gamma Knife Department which conducted for the first time in Iraq.

60 patients were included in this study, meningioma 25 cases in different locations,15 cases of vestibular schwannoma (VS), 10 pituitary macroadenoma (PA) and arteriovenous malformations (AVM) 10 cases.

All are more than 3cm in maximum diameter by radiologist report, 75% were treated primarily by SRS and diagnosed based on their radiological characteristic of the lesions and 15% were residual or recurrent after surgery and diagnosed as WHO grade 1 by histopathological examination.

The study included patients from June 2017 to February 2021 treated by 2-3 sessions, time between sessions range from 24hour to 6months, follow up time ranged from (6ms to 3yr), the lesions were staged according to their volume (volume staged radiosurgery).

History taken and examination done for all cases and were sent for routine investigations in form of complete blood count, renal function test, virology screen, bleeding profile, hormonal assay and visual perimetry for pituitary lesions, pure tone audiometry for vestibular schwannoma and 1.5 or 3 Tesla contrast Brain MRI with Gamma Protocol.

Radiosurgery was performed using the Leksell Gamma Knife® Perfexion™, Cobalt 60.

The procedure begins with Leksell frame application to patient head which helps to prevent movement of the head under local anaesthetic with 2% lidocaine in four regions (one on each side of forehead and two in the back of the head) where pins will be placed, then measurement taken to be used for planning treatment.

Then patients sent to do CT scan with his frame and during this time patient's information are registered in patient management to insert his name, age, gender, date of birth, type of treatment and also provisional diagnosis with detailed site of lesion and operator ID and Name also included in patient management.

Measurement are entered in planning treatment with selecting (frame cap fit) from skull definition then Patient MRI gamma protocol is inserted and images are imported.

CT scan images which are received from Radiology department are defined and MRI co registered with CT to be merged as one image.

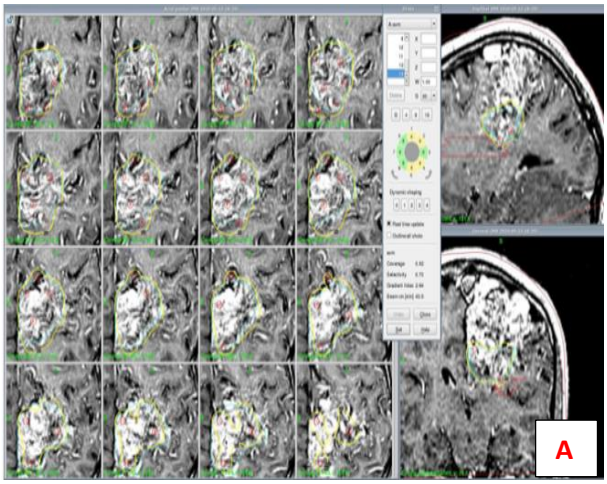
Then we select volume as (target and risk) and manually draw the exact target by dividing the lesion into multiple sections (upper or lower, medial or lateral, anterior or posterior). target volume drawing in the next session skipped the 10-percentile gray zone to avoid radiation necrosis in overlap zone.

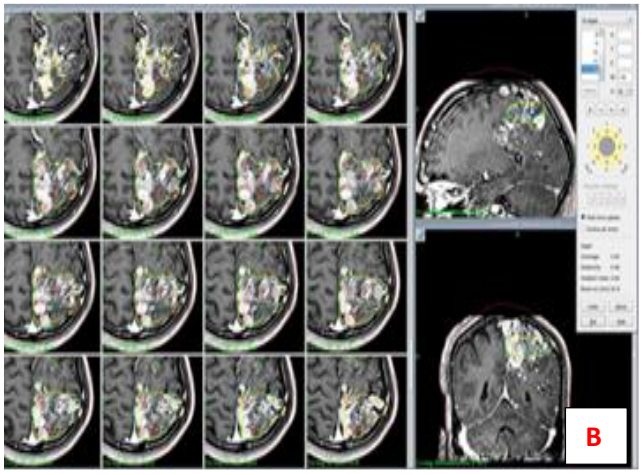
The risk volume drawn to shield the nearby critical structures. in addition to sector block, the measurement of radiation is taken to ensure that nearby structures is receiving tolerable dose of radiation.

A new plan dose setting is done as 50% isodose after that apply shots to the selected target with different beam size of 4,8,16 mm. snapshot taken to be printed, then the plan approved and exported to main panel control and patient is guided to the gamma radiosurgery room and operation is completed by removal of frame, sterilizing pin hole sites with iodine.

Most patients discharging home, few of them admitted to the ward for follow up for 1-2 days.

Data of the 60 patients in this study were entered and analyzed using the statistical package for social sciences (SPSS) version 26, IBM, US, 2019.





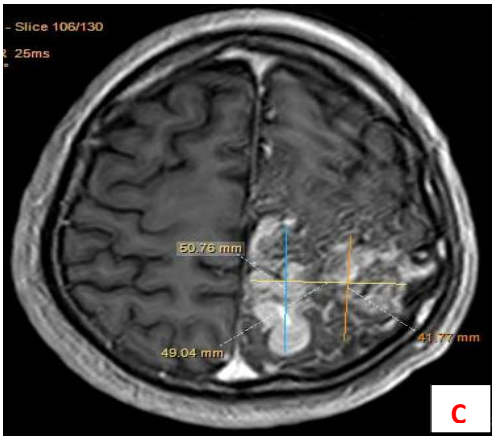
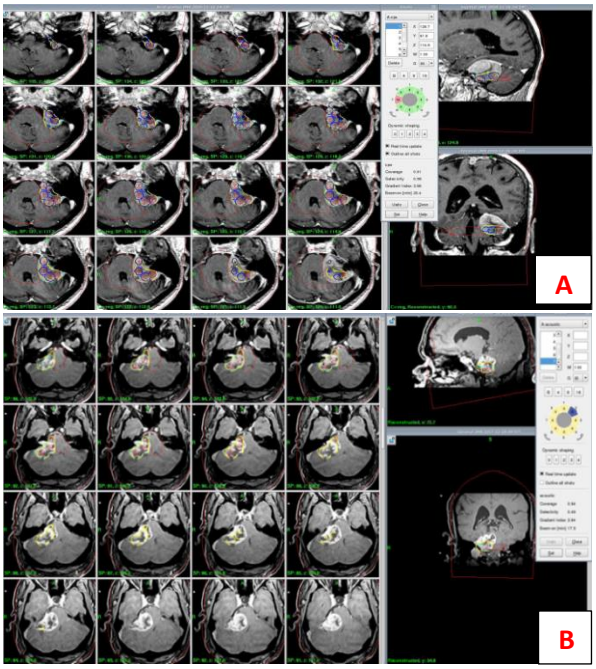


Fig-1 (Case of SM 5 AVM) A-1st session , B- 2nd session ,C-post GK
From Dr.Saad Alwittry hospital-GK department



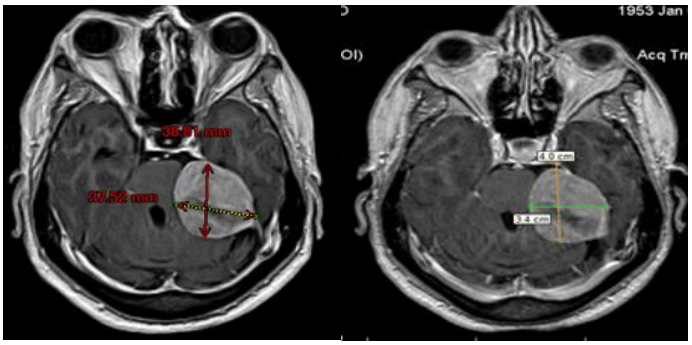
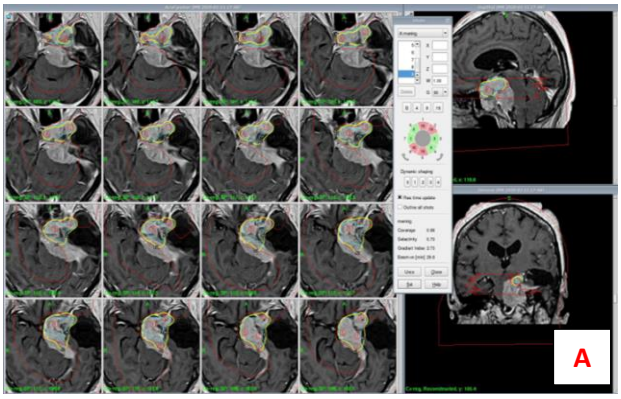


Fig-2 (Case of VS) A-1st session , B- 2nd session ,C-post GK
From Dr.Saad Alwitry hospital-GK department



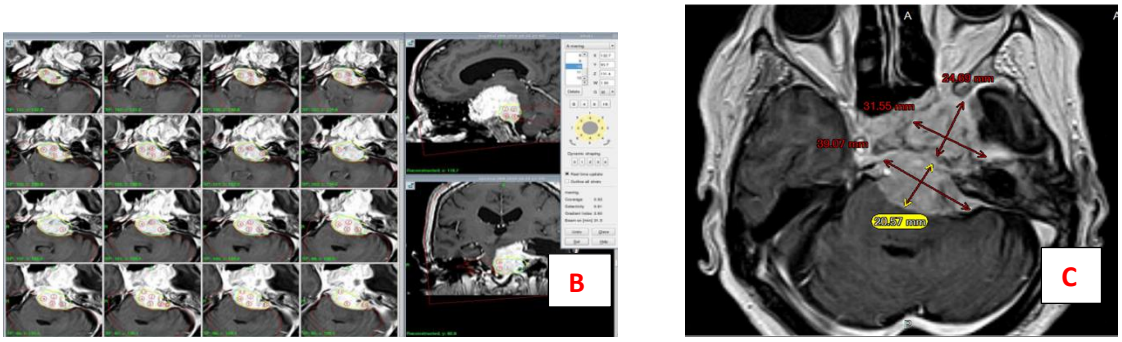


Fig -3 (case of sphenopetro-clival meningioma)

A-1st session , B- 2nd session ,C-post GK
From Dr.Saad Alwitry hospital-GK department

RESULTS

A total of 60 patients were enrolled in this study, 25 of them (41.7%) with Meningioma , 15 (25%) Vestibular Schwannoma, 10 (16.7%) AVM and 10 (16.7%) with Pituitary macro adenoma.

The mean age of the studied group was 48.8 (range: 16 – 72) years , females were relatively dominant, 51.7% vs. 48.3%, respectively, these baseline characteristics in addition to past medical and surgical history, are shown in (Table 1).

Table 2 shows the Method of diagnosis and Locations of Meningiomas.

In (table 3) the median number of sessions was 2, however, 3 patients performed three sessions, median duration between sessions ranged 1 to 180 days , and the doses ranged 10 – 14 Gy.

As shown in table 4, no significant change in the size of meningioma after GK sessions(stabilization of growth),(P>0.05) , nonetheless, size was decreased in 5 patients (20%).

A significant change was reported in the signs and symptoms after GK sessions, headache and seizures were significantly better , (P<0.05). While no significant change in Neural deficit, (P>0.05), (Table 5).

Unfortunately, Some complications were reported among the 25 meningioma patients with one death , (Table 6).

Similarly, characteristics , responses and outcomes of patients in other groups are summarized in the next tables, (7 – 22).

Table 1. Baseline characteristics of the studied group (N = 60)

Variables		No	%
Diagnosis	Meningioma	25	41.7
	Vestibular Schwanoma	15	25.0
	AVM	10	16.7
	Pituitary macro adenoma	10	16.7
Sex	Female	31	51.7
	Male	29	48.3
Past medical history	Hypertension	18	30.0
	DM	8	13.3
	COPD/Asthma	7	11.7
	IHD	4	6.7
Past neurosurgical history	Craniotomy	6	10.0
	Embolization	1	1.7
	Shunt	3	5.0
	TSS	3	5.0

Table 2. Method of diagnosis and Locations of Meningiomas (N = 25)

	No.	%
Method of diagnosis		
Imaging	22	88.0
Histopathology	3	12.0
Location		
Sphenoid wing	6	24.0
Sphenopetroclival	5	20.0
CPA	3	12.0
Cavernous	2	8.0
Foramen magnum	2	8.0
Parasagittal	2	8.0
Tentorial	2	8.0
Clival	1	4.0%
Convexity	1	4.0%
Olfactory	1	4.0%

Table 3. GK sessions related parameters in meningioma group (N = 25)

	Median	Range
Number of sessions	2	2 – 3
Duration between session (days)	30	1 – 180
Dose for 1st session (Gy)	14	12 – 14
Dose for 2nd session(Gy)	12	10 – 14
Dose for 3rd session(Gy)	12	12 – 12

Table 4. Size of meningioma before and after GK session (N = 25)

Size of lesion (mm)		No.	%	Mean Time (months)	P. value
Size before GK	Median	68	-		
	Range	50 – 130	-		
Size after GK	Decrease	5	20.0%	18	0.824 ns
	Same	19	76.0%	11	
	Increase	1	4.0%	9	

Table 5. Signs and symptoms before and after GK sessions in meningioma group (N = 25)

Signs/ symptoms		Pre GK		Post GK			P. value
		No.	%	Response	No.	%	
Headache	Yes	25	100.0	Better	22	88.0	**<0.001 sig**

				Same	0	0.0	
				Worse	3	12.0	
	None	0	0.0	-			
Seizure	Yes	2	8.0	Better	2	100.0	**<0.001 sig**
				Same	0	0.0	
				Worse	0	0.0	
	None	23	92.0	-			
Neural deficits	Yes	14	56.0	Better	10	71.4	**<0.026 sig**
				Same	1	7.2	
				Worse	3	21.4	
	None	11	44.0	-			

Table 6. Complications and outcomes of patients with meningioma after GK sessions (N = 25)

Outcome/ complications		No.	%
Need Surgery	Craniotomy	1	4.0
	Shunt	1	4.0
Complications	Pinhole infection	1	4.0
	Skin reaction & hair loss	2	8.0
	Edema	1	4.0
	Headache	3	12.0
	Radiation necrosis	2	8.0
	Seizure	1	4.0
	Neural deficit	3	12.0
	Death	1	4.0
	Malignant tumor	0	0.0

Table 7. GK sessions related parameters in Vestibular Schwannoma group (N = 15)

	Median	Range
Number of sessions	2	2 – 2
Duration between session (days)	60	1 – 180
Dose for 1st session (Gy)	12	12 – 14
Dose for 2nd session (Gy)	12	10 – 12

Table 8. Size of lesion before and after GK sessions in Vestibular Schwannoma group (N = 15)

Size of lesion (mm)		No.	Mean time (months)	%
Size before GK	Median	50		-
	Range	38 – 77		-
Size after GK	Decrease	5	14.6	33.3
	Same	8	9	53.3
	Increase	2	12	13.4

Table 9. Signs and symptoms before and after GK sessions in Vestibular Schwannoma group (N = 15)

Signs/ symptoms		Pre GK		Post GK			P. value
		No.	%	Response	No.	%	
Vertigo		9	60.0	Better	7	77.8	0.003 sig
				Same	2	22.2	
				Worse	0	0.0	
Headache		15	100.0	Better	9	60.0	0.021 sig
				Same	4	26.7	
				Worse	2	13.3	
SNHL	Mild	5	33.3	Same	14	93.3	0.992 ns
	Severe	10	66.7	worse	1	6.7	
Facial palsy	Mild	7	46.7	Same	13	86.7	0.995 ns
	severe	7	46.7	worse	2	13.3	
	None	1	6.7	None	0	0.0	
Long tracs signs	Mild	5	33.3	Better	3	20.0	0.871 ns
	severe	1	6.7	Same	3	20.0	
	None	9	60.0	Worse	1	6.7	
				None	8	53.3	

Table 10. Complications and outcomes of patients with Vestibular Schwannoma group (N=15)

Outcome		No.	%
Need surgery		1	6.7
Need shunt		2	13.4
Complications	Headache	4	26.8
	Pinole site infection	2	13.4
	Skin reaction & hair loss	2	13.4
	Worsening of facial palsy	2	13.4
	New or Worsening of brainstem signs	2	13.4%
	hearing deterioration	1	6.7%
	Facial hyposthesia	2	13.4%
	Radiation necrosis	1	6.7%
	Death	0	0.0
	Malignant tumor	0	0.0

Table 11. SM grading of AVM (N=10)

	No.	%
Method of diagnosis		
CTA	8	80.0%
MRI+contrast	2	20.0%
SM grade		
3	2	20.0%
4	5	50.0%
5	3	30.0%

Table 12. GK sessions related parameters in AVM group (N = 10)

	Median	Range
Number of sessions	2	2 – 3
Duration between sessions (days)	50	1 – 120
Dose for 1st session (Gy)	15	14 – 16
Dose for 2nd session (Gy)	14	12 – 16
Dose for 3rd session (Gy)	13	12 – 14

Table 13. Size of lesion before and after GK session in AVM group (N = 10)

Size of lesion (mm)		No.	Mean time (Months)	%
Size before GK	Median	60		-
	Range	40 – 150		-
Size after GK	Decrease	7	21.8	70.0
	Same	3	18.3	30.0

Table 14. Complications and outcomes of patients with AVM (N=10)

Complications	No.	%
Headache	2	20.0
Pinhole site infection	1	10.0
Skin reaction & hair loss	1	10.0
Neural deficit	1	10.0
Hemorrhage	1	10.0
Death	1	10.0
Malignant tumor	0	0.0

Table 15. Signs and symptoms before and after GK sessions in AVM group (N = 10)

Signs/ symptoms		Pre GK		Post GK			P. value
		No.	%	Response	No.	%	
Headache	Yes	9	90.0	Better	6	66.7	**0.032 sig**
				Same	3	33.3	
				Worse	0	0.0	
	None	1	10.0	-	-		
Seizure	Yes	9	90.0	Better	7	77.8	**0.015 sig**
				Same	2	22.2	
				Worse	0	0.0	
	None	1	10.0	-	-		
Neural deficit	Yes	4	40.0	Better	3	75.0	**0.029 sig**
				Same	0	0.0	
				Worse	1	25.0	
	None	6	60.0	-	-		

Table 16. Method of diagnosis of Pituitary macro-adenoma (N = 10)

Method of diagnosis	No.	%
Hormonal assay + Histopathology + Imaging	3	30.0%
Hormonal assay + Imaging	7	70.0%

Table 17. GK sessions related parameters in Pituitary macroadenoma group (N = 10)

Parameter	Median	Range
Number of sessions	2	2 – 2
Duration between session (days)	30	1 – 120
Dose for 1st session (Gy)	19	16 – 22
Dose for 2nd session (Gy)	18	12 – 20

Table 18. Size of lesion before and after GK session in Pituitary macro adenoma group (N = 10)

Size of lesion (mm)		No.	Mean time (Months)	%
Size before GK	Median	44		
	Range	38 – 55		
Size after GK	Decrease	3	9	30.0
	Same	6	12.2	60.0
	Increase	1	24	10.0

Table 19. Signs and symptoms before and after GK sessions in Pituitary macro-adenoma group (N = 10)

Signs/ symptoms		Pre GK		Post GK			P. value
		No.	%	Response	No.	%	
Headache	Yes	9	90.0	Better	8	88.9	0.001 sig
				Same	1	11.1	
				Worse	0	0.0	
	None	1	10.0	-			
Vision impairment	Yes	4	40.0	Better	4	100	**<0.001 sig**
				Same	0	0	
				Worse	0	0	
	None	6	60.0	-			
Cranial nerve deficit	Yes	0	0.0	Yes	1	10	0.317 ns
	None	10	100.0	None	9	90	
Hormone related symptoms	Yes	4	40.0	Better	3	75.0	**0.029 sig**
				Same	1	25.0	
	None	6	60.0	-	-		

Table 20. Complications and outcomes of patients with Pituitary macro adenoma (N=10)

Complication	No.	%
Pinhole site infection	1	10.0
Skin reaction & hair loss	1	10.0
Headache	2	20.0
Radiation necrosis or apoplexy	0	0.0
Cranial nerve palsy	1	10.0
Visual impairment	1	10.0
Death	0	0.0
Hypopituitarism	0	0.0
Malignant tumor	0	0.0

Table 21. overall clinical status and complications

Lesion	**Clinical improvement rate %**	**Clinical Stabilization rate%**	**Clinical worsening rate%**	**Complications rate %**
Meningioma	86.4	2.4	11	15
Vestibular schwannoma	52.6	49.8	6.7	15.6
AVM	73.2	18.5	8.3	15

Pituitary macroadenoma	88	12	6.7	15
Overall	75	20.7	8.2	15.2

Table 22. overall Growth control rate

	Growth control rate					
Lesions	**Stable %**	**Mean time (M)**	**Decrease %**	**Mean time(M)**	**Increase %**	**Mean time(M)**
Meningioma	76	11	20	18	4	9
VS	53.3	9	33.3	14.6	13.4	12
AVM	30	18.3	70	21.8	-	-
PA	60	12.2	30	9	10	24
Overall	54.8	12.6	38.3	15.9	9.1	15

DISCUSSION

The LGK was conceived by Lars Leksell as an alternative to an open surgical procedure Which traditionally been a single-fraction treatment modality , now been extended to multiple sessions.

Although surgical resection remain the standard for these large lesions, but some common lesion locations (e.g., skull base meningioma , AVM in eloquent area) are not readily amenable to complete resection because of the proximity of vital neural and vascular structures. Advanced age comorbidities (ischemic heart disease in recent past, uncontrolled diabetes mellitus / hypertension) ,increasing the morbidity and mortality of surgery.

In our study , 60 patients were engaged in this study , 25 of them (41.7%) with Meningioma , 15 (25%) Vestibular Schwannoma, 10 (16.7%) AVM and 10 (16.7%) with Pituitary macroadenoma.

The mean age of the studied group was 48.8 (range: 16 – 72) years , females were relatively dominant, 51.7% vs. 48.3%, respectively. 60.5% having comorbidity,38% were elderly.

In the Majority(75%) of cases the diagnosis is depend on imaging only, about 15% was having histopathological confirmation by previous craniotomy which were residual or recurrent lesions.

The time that used to assess radiological growth control depend on last follow up MRI from the last session of GK.

For meningiomas which were the highest number of cases, mean age was 53.3years ,62% were more than 65 years,65% having comorbidity. Common locations included in this study were (Sphenoid wing 24% and Sphenopetroclival 20 %) which carry high surgical morbidity.

Only 12% (3 cases) had confirmed diagnosis of meningioma WHO grade l by previous craniotomy. Tumors were divided into sections and given GK ,the median dose was 12 Gy (10-14), duration between sessions were 30 days(1-180) ,mean tumor size were 86mm (50-130) ,tumor growth was stable in 76% of patients in mean time of 11 months and decrease in 20% in mean time of 18months while one case show increase in tumor size due to radiation necrosis according to radiological report after 9months from last session. Clinical signs and symptoms improved in majority of cases ,only one case required surgical resection after increment in tumor size with clinical deterioration.

Complications were 1 pinhole site infection,2 skin reaction, perilesional edema 1, radiation necrosis 2, new neural deficit develop in 3 patients with 1 death case of 70 years old male with huge sphenopetro- clival meningioma develop radiation necrosis and treated conservatively , no new tumor development.

Yoshiyasu Iwai and coworkers (2019) in their study of 27 patients with large skull base meningiomas who underwent volume-staged GK at the Osaka City General Hospital (Osaka, Japan) between March 1995 and September 2018 were reviewed. The mean tumor diameters ranged from 31 to 47.8 mm (median 39.4 mm), The prescribed radiation dose was 8-12 Gy (median 10 Gy). The treatment interval between the first and second session was three to nine months (median 5.5 months). The median duration of follow-up after the first session was 84 months (range 6-204 months), Tumor volume decreased in nine (37.5%) patients, remained stable in nine (37.5%), and increased (local failure) in six (25%). The actuarial progression-free local control rate was 88% at three years, 78% at five years, 70% at 10 years, and 70% at 15 years. Neurological status improved in three (12.5%) patients, was unchanged in 16 (66.5%), and deteriorated in five (21%). Permanent radiation injury occurred in one (4%) patient.(5)

Our study had showed improvement in growth control and clinical status in a shorter period of time.

For vestibular schwannoma, 15 cases were included, mean age was 65.3 years with 41% being more than 65yr. and 70% have co-morbidities. They are koos stage 3 or 4 (53% stage 4) with average size of 50mm (38-77) ,20% had previous retrosigmoid craniotomy confirm VS WHO grade l , 20% having VP shunt.

Mass was divided into two segments given two sessions , median dose 12 Gy (10-14) ,with median time of 60days (1-180).tumor growth was stable in 53.3% in mean time of 9months, decreased in 33.3% after mean time of 14.6months and increased in 13.4% after 12months . headache and vertigo Improved in 60%,77% respectively. Sensorineural hearing loss and facial palsy remain stable in 93.3% ,86.7% respectively .

Complications were 2 pinhole site infection,2 skin reaction, ,radiation necrosis 1,deterioration of facial palsy in 1case and hearing in 2cases and new facial hypoesthesia in 2 cases with no death or new tumor development while 1 patient (6.7%) need surgery after radiation necrosis and worsening of his condition and 2 need VP Shunt.

For pituitary macroadenoma ,mean age was 44.5yr ,1 case more than 65 yr, 30% had co-morbidities. 3 lesions were residual tumor post Trans-sphenoidal surgery ,2 cases were prolactinoma and 2 cases of GH secreting adenoma , others non-functioning adenoma .

Adenoma mean size was 44 mm (38-55) divided into two parts given two sessions with median dose of 18 Gy (12-22) ,in time frame of 30days (1-120) between sessions.

Tumor size was control in 60% in mean time of 12.2months, decrease in 30% of cases after a mean time of 9months and 10% show enlargement by MRI report after 24 months since last session. headache improved in 88.9% ,4 cases were having visual field defect by perimetry which improved by GK. 3 (75%) patients were diagnosed with secretory adenoma show biochemical and clinical improvement.

Pinole site infection ,Skin reaction reported in 1 case, 3rd nerve palsy and Visual impairment developed in one patient, while no Radiation necrosis or apoplexy ,death ,hypopituitarism and Malignant tumor have been reported.

For AVM , 10 patients were included ,50% had spetzler martin(SM) grade 4, 30% SM 5, 20% SM 3. Mean age was 31yr ,10% had co-morbidity. Mean nidus size was 60 mm (40-150), given 2-3 sessions of GK, duration between sessions were 50 days (1-120) ,median dose given was 14 Gy (12-16).

Rate of reduction of nidus size was 70% in mean time of 21.8months while 30% remain the same after a mean time of 18.3 months and no case of complete obliteration. Headache ,seizure and neural deficits were improved in 66.7%, 77.8% and 75% respectively.

Complications reported in 10%(1 case) which were Pinhole site infection, skin reaction & hair loss ,new neural deficits .1 patient develop hemorrhage after 3months of GK and died ,no malignant tumor developed.

Kano and coworkers (2012) reported 47 patients having staged-volume AVM radiosurgery at the University of Pittsburgh. The median AVM volume was 22.2 cm 3 ; the median AVM margin dose used at each procedure was 16 Gy. Obliteration was confirmed in 17 patients (36%) at a median follow-up of 87 months. Ten patients (21%) had bleeding after radiosurgery; five patients died. Two patients (4%) developed symptomatic radiation-related complications.(6)

Pollock and coworkers (2016) Retrospective comparison of 381 AVM patients having SRS during a 20-year period , Obliteration was 59.1% at 4 years and 85.1% at 8 years. The ICH rate was 7.7% at 4 years and 10.6% at 8 years. The rate of permanent radiation induced complications was 4.4% at 4 years and 8.6% at 8 years. (7)

Both of these studies involve large sample size and long duration of follow up that make comparison unreasonable.

Overall rate of growth control was 76% in 11months for meningioma, 53.3% in 9months for VS ,30% in 18.3 months for AVM and 60% in 12.2 months for PA ,while decrease in size was seen in 20% in mean time of 18months for meningioma, 33.3% in 14.6months for VS and 70% in 21.8 months for AVM and 30% in 12.2months for PA, so the staged GK is effective in tumor control and size enlargement was seen in 4% ,13.4 %, 10 % in (9m-12m-24m) for meningioma ,VS and PA respectively.

Overall clinical improvement was seen in 86.4 %,52.6% ,73.2% and 88% for meningioma ,VS, AVM and PA respectively that was significant . while clinical worsening was 11%, 6.7%, 8.3% and 6.7% for meningioma , VS, AVM and PA respectively.

Overall complications rate were 15.2% ,the radiation induced complications is 5% and mortality was 3%(2 cases).

CONCLUSION

we conclude that volume staged multisession gamma knife radiosurgery is effective in control of tumor growth of these large lesions in following descending order meningioma, PA, VS and AVM and improvement in patient signs and symptoms in following descending order PA, meningioma, AVM and VS.

Volume staged MSRS is safe and well tolerated with acceptable rate of radiation induced complications and mortality.

RECOMMENDATION

mSRS is promising non-invasive approach so we advise volume staged multisession gamma knife for these large benign lesions , long-term follow up is recommended to investigate the impact of mSRS in large brain lesions, comparative study between volume staged and fractionated multisession GKSRS and study of optimal time between multiple sessions and its correlation with growth control and morbidity.

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