



## Radiosurgery for Skull Base Meningiomas – Long-term Follow-up Report

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### Introduction

Gamma-knife radiosurgery (GKRS) is well-established in the management of inaccessible, recurrent, or residual benign skull base meningiomas. Most series report clinical outcome parameters and complications in the short to intermediate period after radiosurgery. Reports of long-term tumor control and neurological status are still lacking. We report the presentation, treatment, and long-term outcome of skull base meningiomas after GKRS.

### Learning Objectives

In the present study, we reviewed the presenting features, treatment parameters as well as clinical and radiological outcome in patients treated with single-session Gamma Knife radiosurgery (GKRS) for benign WHO-I skull base meningiomas having a minimum follow-up of 60 months.

Table 1 – Patient Related Parameters			
Parameter	Value		
Cohort size	135		
Males: Females Gender	54.1 / 45.9 % (n=73 / 62)		
Age (years) at the time of GKRS* (Median)	54 (range 19-80)		
Median KPS** at the time of GKRS	80 (range 50-100)		
Pre- GKRS Functional Status	KPS at the time of GKRS	≤50	5.2% (n=7)
		60-80	65.9% (n=89)
	Pre-existing neurological deficit	90-100	28.9% (n=39)
		Yes	88.1% (n=119)
		None / Minor	11.9% (n=16)

\*Gamma Knife Radiosurgery  
\*\*Karnofsky Performance Scale

Table 2 – Tumor Related Parameters		
Parameter	Value	
Tumor Volume at time of GKRS* (Median)	4.7 cm <sup>3</sup> (range 0.5-23)	
Tumor Location	Overlap	35.6% (n=48)
	Parasagittal	11.1% (n=15)
	CP angle	11.1% (n=15)
	Clivus	10.4% (n=14)
	Falx	9.6% (n=13)
	Tentorial	5.9% (n=8)
	Petroclival	5.9% (n=8)
	Petroclinoid	5.2% (n=7)
	Petrous	3.7% (n=5)
	Clinoid	1.5% (n=2)
Tumor Abutting / Invading Venous structures	6.7% (n=9)	
Peritumoral Edema	Absent	54.8% (n=74)
	Present	45.2% (n=61)

\*Gamma Knife Radiosurgery

### Methods

From a prospectively collected IRB approved database, we selected patients with a WHO grade I skull base meningioma treated with a single-session GKRS and a minimum of 60 months follow up. 135 patients, 54.1% males (n=73) form the cohort. Median age was 54 years (19-80). Median tumor volume was 4.7 cm<sup>3</sup> (0.5-23). Median margin dose was 15 Gy (7.5-36). Median follow up was 102.5 months (60.1-235.4). Patient and tumor characteristics were assessed to determine predictors of neurological function and tumor progression.

Table 3 – Radiosurgical and Prior Treatment Related Parameters			
Parameter		Value	
Number of Prior Surgeries	Median	1 (range 0-4)	
	0	36.3% (n=49)	
	1	54.1% (n=73)	63.7% (n=86)
	2	8.1% (n=11)	
	≥3	1.5% (n=2)	
Tumor resection grade (Simpson's)	1	8.1% (n=11)	63.7% (n=86)
	2	34.8% (n=47)	
	3	5.2% (n=7)	
	4	13.3% (n=18)	
	5	2.2% (n=3)	
Prior embolization		43% (n=58)	
Median Margin dose (Gy)		15 Gy (Range 7.5-36)	
Median Maximal dose (Gy)		34 Gy (Range 20-65)	
Median Isodose line (%)		40% (Range 28-80)	
Median No. of isocenters		5 (Range 1-25)	

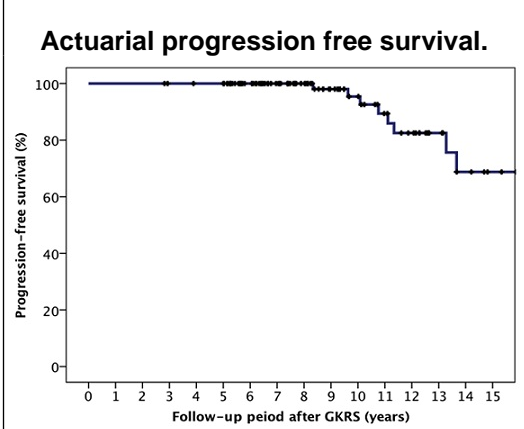


Table 4 – Outcome Parameters		
Parameter	Value	
Cranial nerve deficits (all causes)	22	
Post-GKRS craniotomy due to tumor growth	8.1% (n=11)	
Adverse radiation effects (ARE's)	7.4% (n=10)	
	Median Time to Peak ARE'S (months)	12 (range 6-36)
Median Maximum Edema index	2.8 (Range 0.4-16.8)	
GKRS induced complications	Intermittent Headache	34.8% (n=47)
	Cranial deficit	14.8% (n=20)
	Dizziness	15.6% (n=21)
	Weakness	11.1% (n=15)
	Encephalopathy	3.7% (n=5)
	Pain	1.5% (n=2)
	New or worsening seizures	0.7% (n=1)
	Trigeminal (CN-V)	10.4% (n=14)
GKRS induced cranial nerve deficit	Vestibulocochlear (CN-VIII)	7.4% (n=10)
	Optic (CN-II)	6.7% (n=9)
	Facial (CN-VII)	5.9% (n=8)
	Hypoglossal	2.2% (n=3)
	Oculomotor (CN-III)	2.2% (n=3)
	Vagus (CN-X)	1.5% (n=2)
	Abducens (CN-VI)	0.7% (n=1)
Post-GKRS overall improvement	61.5% (n=83)	
Tumor Control	88.1% (n=119)	
Tumor progression	11.9% (n=16)	
Median Change in KPS last follow-up	+10 (Range -30 to +30)	
KPS at last follow-up	Median	90 (Range 40-100)
	≤ 50	3.7% (n=5)
	60-80	31.9% (n=43)
	≥ 80	64.4% (n=87)
Follow-up	Median (months), Range	102.5 (Range 60.1-235.4)

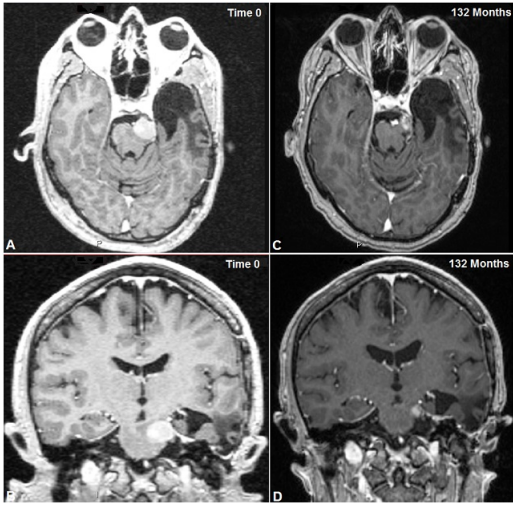
### Results

At last follow up, tumor volume control was achieved in 88.1% (n=119). Post-GKRS clinical improvement or stability was reported in 61.5%. The 5, 10, and 15 years actuarial progression free survival rates are 100%, 95.4%, 68.8% respectively. Favorable outcome (both tumor control and clinical preservation / improvement) was attained in 60.8% (n=79). Pre-GKRS performance status (KPS) was shown to influence tumor progression (p=0.0001) and post-GKRS clinical improvement / preservation (p=0.003).

### Conclusions

GKRS offers a highly durable rate of tumor control for WHO-I skull base meningiomas, with an acceptably low incidence of neurological deficits. KPS at the time of radiosurgery serves as a reliable long-term predictor of outcome.

### 60 year old male patient treated for a left tentorial petroclival meningioma abutting the midbrain



### Correlation between Pre-GKRS KPS and Post-GKRS KPS.

