

Long-term Results of Stereotactic Radiosurgery for Skull Base Meningiomas Or Cohen-Inbar MD, PhD; Cheng-Chia Lee; David Schlesinger; Zhiyua Xu; Jason P. Sheehan MD, PhD, FACS

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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 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.

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≤50 60-80 90-100 Preexisting neurological deficit Yes None/minor	
60-80 90-100 Preexisting neurological deficit Yes None/minor	5.2% (n = 7)
90-100 Preexisting neurological deficit Yes None/minor	65.9% (n = 89)
Preexisting neurological deficit Yes None/minor	28.9% (n = 39)
Yes None/minor	
None/minor	88,1% (n = 119)
	11.9% (n = 16)
Tumor volume (median) at	4.7 cm ³ (range 0.5-23)
time of GKRS	
Tumor location	
Parasagittal ^b	17% (n = 23)
Cerebellopontine angle	17% (n = 23)
Clivus	15.6% (n = 21)
Falx	14.8% (n = 20)
Tentorial	9.6% (n = 13)
Petroclival	9.6% (n = 13)
Petroclinoid	8.1% (n = 11)
Petrous	5.9% (n = 8)
Clinoid	2.2% (n = 3)
Tumor abutting/invading	6.7% (n = 9)
venous structures	
Peritumoral edema	
Absent	54.8% (n = 74)
Present	45.2% (n = 61)
Number of previous surgeries	
Median	1 (range 0-4)
0	36.3% (n = 49)
7	54.1% (n = 73) 63.7% (n = 8
2	8.1% (n = 11)
23	1.5% (n = 2)
lumor resection grade (Simpson)	63.7% (n = 86)
at time of last surgery before GKRS	
1	8.1% (n = 11)
2	34.8% (n = 47)
3	5.2% (n = 7)
4	13.3% (n = 18)
5	2.2% (n = 3)
Previous empolization	43% (n = 58)
Median margin dose, Gy	15 (range 7.5-36)*
Median maximal dose, Gy	34 (range 20-65)*
Median isodose ine, %	40 (range 28-80)

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 cm3 (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.

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Parameter	Value
Cranial nerve deficits (all causes)	22
Post-GKRS craniotomy due to tumor	8.1% (n = 11)
Adverse radiation effects (AREs)	7.4% (p = 10)
Median time to peak AREs (mo) after initial GKRS	12 (range 6-36)
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)
GKRS-induced cranial nerve (CN) deficit	
Trigeminal (CN-V)	10.4% (n = 14)
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 neurological preservation or 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)
Favorable outcome (tumor control and neurological preservation/improvement)	60.8% (n = 79)
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	

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%, and 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).

	Year	Patients	Follow-up (mo)	PFS (%)	5-Year Recurrence/PFS (%)	PES (%)	PFS IN
Nowak et al**	2015	225	82	7.2			
Polini et al ⁴²	2015	99	103 (2-324)	23.2			
Du ot of "	2014	106	10 104.5-70.31	14			
Dumrungnachpulkdee	2014	101	32.3	21.5	35% (8)*		
Jung et al ⁴⁴	2014	150	48.4 10.8-242.21	13.3	0.2% (0)	12.0% (0)	
Konovalov et al ⁴⁷	201.8	15,413	24-990	25-40			
Yuan et ol	2013	134	81.6	12.5			
Column Johnson at 197	1010	750	78,000,14,81	11.6			
Sughrue et al ⁶⁵	2010	373	4416-2160		5% (Simpson = 1), 15% (Simpson = 2), 12% (Simpson = 3), 19% (Simpson = 4)		
McGovern et al ¹²	2010	175	66	31-44	29% (Simpson = 1), 20% (Simpson = 2), 20% (Simpson = 3), 80% (Simpson = 4), 50% (Simpson = 5)		
Makasu es al ⁶⁴	2009	123	110 (12-202)	9.3		7.5% (8)	
Notonojan et ol ³⁰	2007	150	102 (15-180)	5	7.3%291.7%	7.3%/79.5%	
hing et alite	2000	398	30 (6-141)		60% (FFS)	20% (PFS)	
Stafford et el ²²	1993	581	N/A	18.2	12%/61%	25%/59%	
Do years of all	1996	119	23.9	10/15	195/625	1000.0000	120.00
Simpson et al ¹⁹	1957	1241	60 16-2400	36	9% (Simpson = 1), 19% Simpson = 2), 29% (Simpson = 3)	2010/0015	12164
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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 longterm predictor of overall outcome.



Sixty-year-old male patient treated for a left tentorial petroclival meningioma abutting the midbrain



44-year-old female treated for a right posterior fossa meningioma. Treatment volume 5.2 mL, given 15 Gy to the50%isodose line.



The correlation between pre-GKRS KPS and post-GKRS KPS grouped according to tumor control (1-tumor progression) andpost-GKRS improvement. GKRS, Gamma knife radiosurgery; KPS, Karnofsky Performance Scale.