# The Geriatric Scoring System (GSS) for Risk Stratification in Meningioma Patients as a Predictor of Outcome in Patients Treated With Radiosurgery

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## Introduction

Meningiomas are the most common primary benign brain tumor. Radiosurgery allows excellent local control. The Geriatric scoring system (GSS) for pre-operative risk stratification and outcome prediction of patients with meningiomas has been previously reported. The GSS incorporates eight tumor and patient parameters on admission. A GSS score higher than 16 was previously reported to be associated with a more favorable outcome. We assessed the validity of the GSS score and its influence on outcome in patients treated with gamma-knife radiosurgery (GKRS).

### Table 1 – The Geriatric Scoring System (GSS)

| Parameter | 1 point | 2 points | 3 points |
|---|---|---|---|
| Size* | >5 cm (>62.5cm³) | 3~5 cm (13.5~62.5 cm³) | <3 cm (<13.5 cm³) |
| Neurological deficit | Progressive | Stable severe | None, minor |
| KPS** | ≤50 | 60-80 | 90-100 |
| Location | Falcine, Parasagittal, foramen magnum | Tentorial, Posterior Fossa Jugular foramen | Convexity, Intraventricular, Sphenoid wing, Tuberculum sellae, Cavernous sinus, Optic nerve |
| Peritumoral Edema | Severe | Mild | None |
| Diabetes Mellitus | Not controlled | Medically controlled | None |
| Hypertension | Not controlled | Medically controlled | None |
| Pulmonary Disease | Severe | Mild | None |

*Size expressed in maximal diameter cm, and converted to volume equivalent.

**Karnofsky Performance Scale

## Methods

Patients treated with single session GKRS for WHO-1 meningioma during 1989-2013 were reviewed. A cohort of 323 patients, 50.2% (n=162) males. Median age was 56 (29-84), and median follow-up was 53.6 (6-235) months. Median tumor volume was 4.5 cm3 (0.2-23). Median margin and maximal doses were 15 Gy (8-36) and 32.3 Gy (20-65), respectively.

### Table 2 – Patient Related Parameters

| Parameter | | Mean |
|---|---|---|
| Male Gender | | 49.4% (n=203) |
| Age (years) at the time of GKRS* | | 56.2 ± 13.1, Median 56 (range 12-84) |
| KPS** at the time of GKRS | | 77 ± 11, Median 80 (range 40-100) |
| KPS at the time of GKRS grouped (GSS) | ≤50 | 3.9% (n=16) |
| | 60-80 | 65.5% (n=271) |
| | 90-100 | 30.7% (n=127) |
| Diabetes Mellitus grouped (GSS) | None | 68.6% (n=284) |
| | Controlled | 22% (n=91) |
| | Not-Controlled | 9.4% (n=39) |
| Hypertension grouped (GSS) | None | 49.8% (n=206) |
| | Controlled | 23.9% (n=99) |
| | Not-Controlled | 26.3% (n=109) |
| Pulmonary disease grouped (GSS) | None | 87.2% (n=361) |
| | Mild | 9.9% (n=41) |
| | Severe | 2.9% (n=12) |
| Neurological Deficit grouped (GSS) | Progressive | 34.5% (n=143) |
| | Stable Severe | 49.3% (n=204) |
| | None / Minor | 16.2% (n=67) |

*Gamma Knife Radiosurgery

**Karnofsky Performance Scale

### Table 3 – Tumor Related Parameters

| Parameter | | Value |
|---|---|---|
| Tumor Volume at time of GKRS* | | 6.3 cm³ (Range 0.1-54.8 cm³) |
| Maximum Tumor diameter at time of GKRS | | 2.76 cm (range 0.7-7.5 cm) |
| Tumor size grouped (GSS) | >5 cm (>62.5cm³) | 2.2% (n=9) |
| | 3~5 cm (13.5~62.5 cm³) | 14.3% (n=59) |
| | <3 cm (<13.5 cm³) | 83.6% (n=346) |
| Tumor Location | Tentorial | 6.3% (n=26) |
| | CP angle | 12.3% (n=51) |
| | Petroclival | 4.8 (n=20) |
| | Petrous | 1.4% (n=6) |
| | Foramen magnum | 1.4% (n=6) |
| | Clivus | 7.7% (n=32) |
| | Clinoid | 1% (n=4) |
| | Petroclinoid | 1.7% (n=7) |
| | Parasagittal | 16.4% (n=68) |
| | Falx | 14.7% (n=61) |
| | Overlap | 30.9% (n=128) |
| Tumor location grouped (GSS) | Falcine / Parasagittal / foramen magnum | 34.3% (n=142) |
| | Tentorial / Posterior fossa / Jugular foramen | 32.4% (n=134) |
| | Convexity / Intraventricular / Sphenoid wing / Tuberculum sellae / Cavernous sinus / Optic nerve | 33.3% (n=138) |
| Venous structures invasion | | 9.8% (n=40) |
| Peritumoral Edema grouped (GSS) | None | 49.8% (n=206) |
| | Mild | 30.2% (n=125) |
| | Severe | 20% (n=83) |
| Tumor grade | 1 | 92% (n=381) |
| | 2 | 6.8% (n=28) |
| | 3 | 1.2% (n=5) |

*Gamma Knife Radiosurgery

## Results

Tumor volume control was achieved in 87% (n=281), and post-GKRS clinical neurological improvement reported in 66.3% (n=214). The median change in KPS was +10 (range -30 to +40). The GSS (calculated and grouped as GSS>16 and GSS<=16) was found to correlate with different Post-GKRS functional status (p<0.0001) and tumor control (p=0.028).

### Table 4 – Radiosurgical and Prior Treatment Related Parameters

| Parameter | | Value |
|---|---|---|
| Number of Prior Surgeries | Median | 1 (range 0-7) |
| | 0 | 40% (n=163) |
| | 1 | 48.2% (n=196) |
| | 2 | 9.1% (n=37) |
| | ≥3 | 2.7% (n=11) |
| Tumor resection grade (Simpson's) | 1 | 4.7% (n=19) |
| | 2 | 25.8% (n=105) |
| | 3 | 6.1% (n=25) |
| | 4 | 8.1% (n=33) |
| | 5 | 0.5% (n=2) |
| | Unknown | 54.8% (n=223) |
| Prior embolization | | 38.8% (n=158) |
| Margin dose (Gy) | Mean | 14.2 ± 2.7 |
| | Median | 15 (range 4.8-30) |
| Maximal dose (Gy) | Mean | 33.7 ± 7 |
| | Median | 32.25 (range 12-65) |
| Isodose line (%) | | 45 (range 15-80) |
| Median No. of isocenters | | 7 (range 1-33) |
| Mean Maximum Edema index | | 3.82 ± 9.89 (range 0-113) |

### Table 5 – Outcome Parameters

| Parameter | | Value |
|---|---|---|
| Post-GKRS seizures | | 26.9% (n=110) |
| Post-GKRS craniotomy due to tumor growth | | 8% (n=33) |
| GKRS induced complications | Headache | 37.4% (n=155) |
| | Weakness | 11.8% (n=49) |
| | New or worsening seizures | 2.4% (n=10) |
| | Encephalopathy | 6.3% (n=26) |
| | Aphasia | 0.2% (n=1) |
| | Dizziness | 18.6% (n=77) |
| | Cranial deficit | 29% (n=120) |
| | Pain | 0.7% (n=3) |
| Post GKRS cranial nerve deficit | Optic (CN-II) | 33.3% (n=40) |
| | Oculomotor (CN-III) | 3.3% (n=4) |
| | Trigeminal (CN-V) | 38.3% (n=46) |
| | Abducens (CN-VI) | 0.8% (n=1) |
| | Facial (CN-VII) | 10% (n=12) |
| | Vestibulocochlear (CN-VIII) | 13.3% (n=16) |
| | Vagus (CN-X) | 0.8% (n=1) |
| Post-GKRS overall improvement | | 64.9% (n=266) |
| Patient outcome | Death from unrelated causes | 4.6% (n=19) |
| | Tumor Control | 50.2% (n=208) |
| | Tumor progression | 41.5% (n=172) |
| | Lost to follow-up | 3.6% (n=15) |
| Change in KPS last follow-up relative to pre-GKRS | Mean | 5.87 ± 13.8 |
| | Range | -30 to +40 |
| KPS at last follow-up | Mean | 82.6 ± 16.4 |
| | Median | 90 (range 40-100) |
| | ≤ 50 | 6.8% (n=28) |
| | 50-70 | 24.7% (n=102) |
| | ≥ 70 | 68.5% (n=283) |
| Follow-up | Mean, months | 68.3 ± 47.2 |
| | Median, Range | 53.6 (6-235) months |
| | 0-60 months | 194 |
| | 61-120 months | 111 |
| | >121 months | 56 |

### Table 6 - Univariate Analysis

| Independent Parameter | Dependent Parameter | Correlation | P |
|---|---|---|---|
| GSS > 16 | Post GKRS improvement | A significant correlation between GSS>16 and post-GKRS improvement | <0.0001 |
| | Post-GKRS Change in KPS at last follow-up | A significant positive correlation between GSS>16 and a higher post-GKRS KPS improvement* | <0.0001 |

*using non-parametric Mann-Whitney U test as well as ANOVA Regression model

### Table 7 - Multivariate Analysis

| Dependent Parameter | Independent Parameter | P |
|---|---|---|
| Post GKRS improvement | GSS > 16 | <0.0001 |
| | GSS calculated (not-grouped) | 0.003 |
| | Maximum Recorded Edema Index | 0.08 |
| | Margin Dose (Gy) | 0.79 |
| | Simpson Grade | 0.43 |
| | Tumor location | 0.88 |
| | Pre-GKRS Tumor Volume | 0.98 |

*Using ANOVA Regression model and Cox regression when applicable.



Tumor Volume Control (Relative Scale, 0=No, 1=Yes)



Post-GKRS Clinial Neurological Preservation/ Improvement (Relative Scale 0 =No, 1=Yes)

## Conclusions

The GSS, used for risk stratification and outcome prediction in patients with meningiomas seems valid for patients undergoing single session GRKS. GSS score greater than 16 is associated with a better long-term functional status and tumor control.