Clinical Role of Mask Based Gamma Knife Radiosurgery

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Clinical Implications of Mask Basked SRS/SRT

- Patient Experience
- Argument for Hypofractionation

- Workflow Disruption
- Quality of Immobilization
Clinical Implications of Mask Basked SRS/SRT

- Patient Experience
- Argument for Hypofractionation
- Workflow Disruption
- Quality of Immobilization
Agenda

I. Theoretical Benefits for Hypofractionation

I. Clinical Indications

- Intact Brain Metastases
- Post-Operative Cavities
- Other Indications
Role of Radiosurgery for Brain Metastases

**Survival: Historical Data**
- 1 month no treatment
- 2 months with steroids
- 4 months with whole brain RT
Role of Radiosurgery for Brain Metastases

Cause of Death:
50% intracranial progression
50% extracranial disease
Can we do better?
# Role of Radiosurgery for Brain Metastases

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment</th>
<th>Local Control</th>
<th>Neurological Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>JROSG 99-1</td>
<td>SRS</td>
<td>72.5%</td>
<td>19.3%</td>
</tr>
<tr>
<td></td>
<td>SRS + WBRT</td>
<td>88.7%</td>
<td>22.8%</td>
</tr>
<tr>
<td>EORTC 22952</td>
<td>SRS/surgery</td>
<td>69%</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>SRS/Surgery + WBRT</td>
<td>81%</td>
<td>28%</td>
</tr>
<tr>
<td>MDA</td>
<td>SRS</td>
<td>67%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>SRS + WBRT</td>
<td>100%</td>
<td>28%</td>
</tr>
<tr>
<td>NCCTG</td>
<td>SRS</td>
<td>72.8%</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>SRS + WBRT</td>
<td>90.1%</td>
<td>NR</td>
</tr>
</tbody>
</table>
Impact of Dose on Control Rates

Local control after radiosurgery for brain metastases: predictive factors and implications for clinical decision

Tâmara Ribeiro de Azevedo Santos, Carmen Freire Tundisi, Henderson Ramos, Maria Aparecida Conte Maia, Antônio Cássio Assis Pellizzon, Maria Letícia Gobo Silva, Ricardo César Fogaroli, Michael Jenwei Chen, Sérgio Hideki Suzuki, José Eduardo Souza Dias Jr, Paulo Issamu Sanematsu Jr, and Douglas Guedes de Castro
SINGLE DOSE RADIOSURGICAL TREATMENT OF RECURRENT PREVIOUSLY IRRADIATED PRIMARY BRAIN TUMORS AND BRAIN METASTASES: FINAL REPORT OF RTOG PROTOCOL 90-05

Edward Shaw, M.D.,* Charles Scott, Ph.D.,† Luis Souhami, M.D.,‡ Robert Dinapoli, M.D.,§ Robert Kline, Ph.D.,‖ Jay Loeffler, M.D.,‖ and Nancy Farnan, B.S.†

Table 5. Incidence of Grade 3, 4, and 5 CNS toxicity by tumor size and treatment arm

<table>
<thead>
<tr>
<th>Tumor size*</th>
<th>Arm</th>
<th>Dose</th>
<th>No. of patients</th>
<th>% of Patients With Toxicty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Acute</td>
</tr>
<tr>
<td>≤ 20 mm</td>
<td>1</td>
<td>18 Gy</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>21 Gy</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>24 Gy</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>21–30 mm</td>
<td>2</td>
<td>15 Gy</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>18 Gy</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>21 Gy</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>24 Gy</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td>31–40 mm</td>
<td>3</td>
<td>12 Gy</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>15 Gy</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>18 Gy</td>
<td>18</td>
<td>17</td>
</tr>
</tbody>
</table>

* Maximum tumor diameter.
Stereotactic radiosurgery for brain metastases: analysis of outcome and risk of brain radionecrosis

V12
Q1: <3.3 cm³
Q2: 3.3 – 5.9 cm³
Q3: 6.0 – 10.9 cm³
Q4: >10.9 cm³
Rationale for Hypofractionation

↑ Local Control

↓ Toxicity
Single versus Multifraction Stereotactic Radiosurgery for Large Brain Metastases: An International Meta-analysis of 24 Trials

Meta-Analysis – 24 Trials

*Intact Brain Metastases*

- **Group A:** 4 – 14 cm³ (2-3 cm)
  - Local Control: 77.6%
  - Single Fraction: 77.1%
  - Multiple Fraction: 79.2%

- **Group B:** >14 cm³ (>3 cm)
  - Local Control: 92.9%
  - Single Fraction: 92.9%
  - Multiple Fraction: 79.2%

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Eric J. Lehrer, MD, MS,* Jennifer L. Peterson, MD,†‡
Nicholas G. Zaorsky, MD,§ Paul D. Brown, MD,‖ Arjun Sahgal, MD,‖
Veronica L. Chiang, MD,¶ Samuel T. Chao, MD,§*
Jason P. Sheehan, MD, PhD,¶¶ and Daniel M. Trifiletti, MD†‡
Single versus Multifraction Stereotactic Radiosurgery for Large Brain Metastases: An International Meta-analysis of 24 Trials

Local Control

Meta-Analysis – 24 Trials
Post-Operative Cavity

- Group B: >14 cm³ (>3 cm)

<table>
<thead>
<tr>
<th></th>
<th>Single Fraction</th>
<th>Multiple Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>62.4%</td>
<td>85.7%</td>
</tr>
</tbody>
</table>
Single versus Multifraction Stereotactic Radiosurgery for Large Brain Metastases: An International Meta-analysis of 24 Trials

Meta-Analysis – 24 Trials

<table>
<thead>
<tr>
<th>Group</th>
<th>Single Fraction</th>
<th>Multiple Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A: 4 – 14 cm³ (2-3 cm)</td>
<td>23.1%</td>
<td>7.3%</td>
</tr>
<tr>
<td>Group B: &gt;14 cm³ (&gt;3 cm)</td>
<td>11.7%</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

Necrosis

Eric J. Lehrer, MD, MS,* Jennifer L. Peterson, MD,†‡
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Jason P. Sheehan, MD, PhD,†† and Daniel M. Trifiletti, MD††
Single-Fraction Versus Multifraction (3 × 9 Gy) Stereotactic Radiosurgery for Large (> 2 cm) Brain Metastases: A Comparative Analysis of Local Control and Risk of Radiation-Induced Brain Necrosis

$P = .01$

Cumulative incidence of local control

Number at risk:

<table>
<thead>
<tr>
<th></th>
<th>Time (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-fraction SRS</td>
<td>179  66  18  8</td>
</tr>
<tr>
<td>Multifraction SRS</td>
<td>164  62  15  7</td>
</tr>
</tbody>
</table>

Giuseppe Minniti, MD, PhD,∗† Claudia Scaringi, MD,∗ Sergio Paolini, MD,∗ Gaetano Lanzetta, MD,∗ Andrea Romano, MD,† Francesco Cicone, MD,† Mattia Osti, MD,∗ Riccardo Maurizi Enrici, MD,∗ and Vincenzo Esposito, MD†
Single-Fraction Versus Multifraction (3 × 9 Gy) Stereotactic Radiosurgery for Large (> 2 cm) Brain Metastases: A Comparative Analysis of Local Control and Risk of Radiation-Induced Brain Necrosis

![Graph showing cumulative incidence of radiation brain necrosis for single-fraction and multifraction SRS with number at risk and time (months)].

**Number at risk:**

<table>
<thead>
<tr>
<th></th>
<th>Single-fraction SRS</th>
<th>Multifraction SRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (months)</td>
<td>0 6 12 24 36 48 60</td>
<td></td>
</tr>
<tr>
<td>Number at risk</td>
<td>179 64 17 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>164 60 14 5</td>
<td></td>
</tr>
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Clinical Benefit of Hypofractionation

- Why may there be improvement in local control with hypofractionation
  - Is it the radiobiology
The radiosurgery fractionation quandary: single fraction or hypofractionation?

John P. Kirkpatrick, Scott G. Soltys, Simon S. Lo, Kathryn Beal, Dennis C. Shrieve, and Paul D. Brown
Clinical Benefit of Hypofractionation

• Why may there be improvement in local control with hypofractionation
  • Is it the radiobiology
  • Is it margins/more generous contouring
Consensus Contouring Guidelines for Postoperative Completely Resected Cavity Stereotactic Radiosurgery for Brain Metastases

• Recommendations
  • CTV include entire surgical tract
  • CTV should include 5 to 10 mm margin along bone flap if initially in contact with the dura, 1 to 5 mm in not in contact
  • CTV 1-5 mm if in contact with venous sinus preoperatively

Hany Soliman, MD,* Mark Ruschin, PhD,* Lilyana Angelov, MD,†
Paul D. Brown, MD,† Veronica L.S. Chiang, MD,†
John P. Kirkpatrick, MD, PhD,† Simon S. Lo, MD,‡ Anita Mahajan, MD,‡
Kevin S. Oh, MD,§ Jason P. Sheehan, MD, PhD,** Scott G. Soltys, MD,**
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and Arjun Sahgal, MD*
Clinical Benefit of Hypofractionation

• Ability to treat Targets that are close to organs at risk
  • Brainstem
  • Optic Nerve
  • Optic Chiasm
Conclusion

• Gamma Knife ICON introduces the ability to use the Gamma Knife platform with a mask based system.

• Introduces the ability to treat with hypofractionation (nominally 2–5 sessions)
  • Clinical Benefit
    • Large Lesions
    • Adjacent to critical structures