38TH ICRO TEACHING COURSE

BENIGN BRAIN TUMORS

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SCOPE OF STUDY

- Meningioma
- Pituitary adenoma
- Vestibular schwannoma
- Craniopharyngioma

- Epidemiology
- Radiology
- Treatment
  - Radiosurgery
- Outcomes
- Outline of radiosurgery technique
MENINGIOMA
MENINGIOMA

- **Extra Axial**
- **Meningocytes or Arachnoid Cap Cells of Meninges**

**Location**
- Supratentorial → 85 – 90%
- Infratentorial → 5 – 10%
- Miscellaneous intradural → 5%

- **Intraventricular**
- **Parafalcine**
- **Sphenoid Wing**
- **Intraosseous**
- **Optic N**
- **Olfactory Groove**

- **Women : Men = 2:1**
- **Intracranial : Spinal = 4:1**
- **Elderly age group > 40 yrs**
- **Younger age in NF2**
MENINGIOMA : HISTOLOGY (WHO)

- **Grade 1 (benign) → 70%**
  - Transitional
  - Meningothelial
  - Fibrous
  - Microcystic
  - Psammomatous
  - Angiomatous
  - Secretory
  - Metaplastic
  - Lymphoplasmacytic rich

- **Grade 2 (atypical) → 30%**
  - Clear cell
  - Choroid meningioma
  - Atypical by histologic criteria
    - Infiltration into brain parenchyma
    - 4 – 9 mitosis per 10 HPF
    - Necrosis
    - Sheet like growth
    - Small cell changes
    - Increased cellularity
    - Prominent nucleoli

- **Grade 3 (anaplastic) < 1%**
  - Rhabdoid
  - Papillary
  - Anaplastic by histologic criteria
    - > 20 mitosis per 10 HPF
    - Obvious malignant features
MENINGIOMA: RADIOLOGY (MRI)

- **Extra axial mass with broad dural base**
- **T1 P**
  - Isointense (60-90%)
  - Hypointense in psammomatous/fibrous type
- **T1 C**
  - Intense homogenous enhancement
- **T2**
  - Iso to hyperintense
  - Hypointense in fibrous/calcified type
- **DWI**
  - Atypical and malignant type may show restricted diffusion
- **MR perfusion is helpful to predict histological grade**
MENINGIOMA : RADIOLOGY (CT)

- **Plain CT**
  - Hyperdense (60%) or isodense
  - Calcification seen (20%)
  - Hyperostosis in skull base lesions

- **Contrast CT**
  - Intensely enhancing (72%)
  - Less enhancement/ cystic changes in high grade
• **Avid in Gallium DOTATATE scan**
• **Helpful in inoperable sites**
• **May predict**
  • **Grade**
  • **Response**
MENINGIOMA: TREATMENT OPTIONS

**Observation**
- Small, asymptomatic tumours
- Serial MRI

**Surgery:**
- More than 3 cm, symptomatic
- Radiologically aggressive

<table>
<thead>
<tr>
<th>Simpson’s Grade</th>
<th>10 yrs recurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade 1</strong></td>
<td></td>
</tr>
<tr>
<td>Complete resection with dura and bone</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Grade 2</strong></td>
<td></td>
</tr>
<tr>
<td>Complete resection with dura</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Grade 3</strong></td>
<td></td>
</tr>
<tr>
<td>Complete resection without dura</td>
<td>29%</td>
</tr>
<tr>
<td><strong>Grade 4</strong></td>
<td></td>
</tr>
<tr>
<td>Subtotal resection</td>
<td>44%</td>
</tr>
<tr>
<td><strong>Grade 5</strong></td>
<td></td>
</tr>
<tr>
<td>Simple decompression/biopsy</td>
<td>100%</td>
</tr>
</tbody>
</table>
MENINGIOMA: TREATMENT OPTIONS

- **ROLE OF RADIOTHERAPY**
  - Observation for completely resected Gr 1 tumors
  - Completely resected Gr 2
    - Consider depending on
      - Possibility of re-resection
      - Rate of growth
      - Mitotic index
      - Neurological status
  - Incompletely resected Gr 2
  - Gr 3
  - Inoperable / Skull base etc
### MENINGIOMA: TREATMENT OPTIONS

Overview of the recent clinical literature on SRS and SRT for meningiomas

<table>
<thead>
<tr>
<th>Author</th>
<th>Institution</th>
<th>Year</th>
<th># of Lesions</th>
<th>% Prior Surgery</th>
<th>Mean Volume (cm³)</th>
<th>Mean Dose (Gy)</th>
<th># of Fractions</th>
<th>% IDL covering PTV</th>
<th>% Local Control</th>
<th>% Tumor Response</th>
<th>% Late Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villavicencio</td>
<td>Brigham and Women's Hospital, Boston</td>
<td>2001</td>
<td>58</td>
<td>64</td>
<td>0.06</td>
<td>15</td>
<td>1</td>
<td>100</td>
<td>95 at 26 months</td>
<td>41</td>
<td>9</td>
</tr>
<tr>
<td>Spiegelmann</td>
<td>The Chaim Sheba Medical Center, Tel Hashomer</td>
<td>2002</td>
<td>42</td>
<td>26</td>
<td>8.20</td>
<td>14</td>
<td>1</td>
<td>72</td>
<td>98 at 36 months</td>
<td>60</td>
<td>7</td>
</tr>
<tr>
<td>Torres</td>
<td>UCLA School of Medicine, Los Angeles</td>
<td>2003</td>
<td>63</td>
<td>66</td>
<td>12.7</td>
<td>16</td>
<td>1</td>
<td>67</td>
<td>92 at 41 months</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Torres</td>
<td>UCLA School of Medicine, Los Angeles</td>
<td>2003</td>
<td>72</td>
<td>66</td>
<td>16.1</td>
<td>48</td>
<td>1</td>
<td>89</td>
<td>97 at 24 months</td>
<td>34</td>
<td>5</td>
</tr>
<tr>
<td>Selch</td>
<td>David Geffen School of Medicine, Los Angeles</td>
<td>2004</td>
<td>45</td>
<td>64</td>
<td>14.5</td>
<td>50</td>
<td>28</td>
<td>90</td>
<td>97 at 36 months</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Candish</td>
<td>BC Cancer Agency, Vancouver</td>
<td>2006</td>
<td>36</td>
<td>28</td>
<td>8.90</td>
<td>50</td>
<td>28</td>
<td>90</td>
<td>100 at 26 months</td>
<td>NA</td>
<td>6</td>
</tr>
<tr>
<td>Hamo</td>
<td>Helios Klinikum, Erlurt</td>
<td>2006</td>
<td>65</td>
<td>69</td>
<td>18.9</td>
<td>54</td>
<td>30</td>
<td>90</td>
<td>100 at 45 months</td>
<td>54</td>
<td>3</td>
</tr>
<tr>
<td>Yenice</td>
<td>Memorial Sloan-Kettering Cancer Center, New York</td>
<td>2006</td>
<td>7</td>
<td>57</td>
<td>7.80</td>
<td>54</td>
<td>30</td>
<td>100</td>
<td>100 at 17 months</td>
<td>71</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Highly Conformal Techniques**
- **Conventional dose 45-54 Gy**
- **SRS dose 14-16 Gy**
VESTIBULAR SCHWANNOMA
Acoustic neuroma on vestibulocochlear nerve puts pressure on facial nerve
RADIOLOGICAL APPEARANCE

- CT Plain & Contrast
- MRI T1 (Plain & Contrast)
- MRI T2
- MRI T2 Contrast (BTFE / CISS)
CT PLAIN & CONTRAST

• **EROSION & WIDENING OF IAM**
• **PLAIN CT:**
  • VARIABLE INTENSITY
  • POOR VISIBILITY DUE TO ARTIFACTS FROM PETROUS BONE
• **CONTRAST CT:**
  • IRREGULAR ENHANCEMENT
  • CYSTIC COMPONENTS
MRI T1 (P&C), T2

- **T1 Plain**
  - Slightly hypo-intense - 63%
  - Iso intense - 37%
  - May contain hypo-intense cystic areas

- **T1 Contrast (Gd)**
  - Contrast enhancement is vivid
  - Heterogeneous in larger tumors

- **T2**
  - Heterogeneously hyper intense
  - Cystic areas fluid intensity
  - May have associated peri-tumoural arachnoid cysts
MRI T1 (P&C), T2

- T2 & Fast Spin Echo: Cochlea
- T2 CISS Contrast: Nerves within IAC
Enhancing

‘Ice cream cone’

Compression of Midbrain

Cystic/Necrotic Change

CSF Cleft
Intracanalicular extension
KOOS STAGING FOR VESTIBULAR SCHWANNOMA

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Small intracanalicular tumor</td>
</tr>
<tr>
<td>II</td>
<td>Small intracanalicular tumor with extension into cerebellopontine angle</td>
</tr>
<tr>
<td>III</td>
<td>Large tumor occupying cerebellopontine cistern without brain stem displacement</td>
</tr>
<tr>
<td>IV</td>
<td>Extremely large tumor with marked displacement of brainstem and cranial nerves</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GR class</th>
<th>Description</th>
<th>Speech Discrimination</th>
<th>Maximal PTA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Good</td>
<td>70-100%</td>
<td>0-30 dB</td>
</tr>
<tr>
<td>II</td>
<td>Serviceable</td>
<td>50-69%</td>
<td>31-50 dB</td>
</tr>
<tr>
<td>III</td>
<td>Nonserviceable</td>
<td>5-49%</td>
<td>51-90 dB</td>
</tr>
<tr>
<td>IV</td>
<td>Poor</td>
<td>1-4%</td>
<td>91 dB to max</td>
</tr>
<tr>
<td>V</td>
<td>None</td>
<td>0%</td>
<td>Not testable</td>
</tr>
</tbody>
</table>
TREATMENT OPTIONS

- Observation
- Surgery
- Stereotactic Radiosurgery/Radiotherapy
WHICH MODALITY TO CHOOSE?

- **No Randomized Trial or Level I Evidence**
- Patient preference
- Available expertise (Neuro-Oncology team)

<table>
<thead>
<tr>
<th>Modality</th>
<th>Fraction Details</th>
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<tbody>
<tr>
<td>SRS</td>
<td>1 Fraction</td>
</tr>
<tr>
<td>FSRT</td>
<td>3 or 5 Fractions</td>
</tr>
<tr>
<td>SRT</td>
<td>More than 5 fractions, up to 27 fractions</td>
</tr>
</tbody>
</table>

- Age
- Size
- Serviceable Hearing
- Recurrence
INTRACANALICULAR COMPONENTS

- Motor branch of Facial N (CN VII)
- Cochlear N (CN VIII)
- Inferior Vestibular N (CN VIII)
- Superior Vestibular N (CN VIII)
PRE TREATMENT PREPARATION

- **Audiological Tests**
  - **Pure Tone Audiometry (PTA)**
  - **Speech Discrimination Score (SDS)**
- **Graded using Gardner Robertson Grading System**
  - **Serviceable Hearing**: PTA<50dB/SDS>50%
- **VII th N function**: House –Brackman Score
- **Pre treatment Steroid**: Controversial
  - 40 mg MPS IV
IDENTIFYING COCHLEA
DOSE / CONSTRAINTS

- **Prescription:** 12 to 13 Gy at periphery of tumor
  - 45 Gy to 54 Gy in SRT
  - Higher doses (~16 Gy) used in the past associated with more neurotoxicity and hearing loss
- VCN < 9 Gy
- V th, VIII th CN > 16 Gy
- Cochlea
  - 12 Gy for single Fr
  - 20 Gy for 3Fr X 6.67 Gy
  - 27.5 Gy for 5Fr X 5.5 Gy
  (Robert Timmerman, Sem Rad Onc, 2008)
- 35-45 Gy for SRT
WHEN TO CONSIDER SRT/FSRT?

• VERY LARGE TUMORS, MORE THAN 20cc
• INTRACANALICULAR EXTENSIONS
• MIDBRAIN COMPRESSION
• RE TREATMENT
## SRS VS. FSRT

<table>
<thead>
<tr>
<th>Series</th>
<th>Year</th>
<th>Number</th>
<th>Hearing</th>
<th>CN VII</th>
<th>CN V</th>
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</thead>
<tbody>
<tr>
<td>Combs et al</td>
<td>2009</td>
<td>SRS (30) FSRT 172</td>
<td>NR</td>
<td>17%</td>
<td>7%</td>
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<tr>
<td>Andrews et al</td>
<td>2001</td>
<td>SRS (69) SRT (56)</td>
<td>33% 65.4%</td>
<td>2% 2%</td>
<td>5% 7%</td>
</tr>
<tr>
<td>Meijer Et al</td>
<td>2003</td>
<td>SRS (49) HFSRT (80)</td>
<td>75% 61%</td>
<td>7% 3%</td>
<td>8% 2%</td>
</tr>
<tr>
<td>Anderson Et al</td>
<td>2007</td>
<td>SRS (49) SRT (20) HFSRT (32)</td>
<td>33.3% 65.4%</td>
<td>2% 2%</td>
<td>10.2% 0%</td>
</tr>
<tr>
<td>Authors &amp; Year</td>
<td>N</td>
<td>Dose</td>
<td>Local Control</td>
<td>Useful Hearing</td>
<td>VII Injury</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>---------------</td>
<td>----------------</td>
<td>------------</td>
</tr>
<tr>
<td>Varlotto, et al., 1996</td>
<td>12</td>
<td>54</td>
<td>100</td>
<td>100</td>
<td>-</td>
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<tr>
<td>Lederman, et al., 1997</td>
<td>38</td>
<td>20</td>
<td>100</td>
<td>-</td>
<td>0</td>
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<tr>
<td>Kalapurakal, et al., 1999</td>
<td>19</td>
<td>30-36</td>
<td>100</td>
<td>-</td>
<td>0</td>
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<tr>
<td>Fuss, et al., 2000</td>
<td>42</td>
<td>57.6</td>
<td>95</td>
<td>100</td>
<td>0</td>
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<tr>
<td>Shirato, et al., 2000</td>
<td>50</td>
<td>36-44</td>
<td>86</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Andrews, et al., 2001</td>
<td>56</td>
<td>50</td>
<td>97</td>
<td>81</td>
<td>2</td>
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<tr>
<td>Szumacher, et al., 2002</td>
<td>39</td>
<td>50</td>
<td>95</td>
<td>68</td>
<td>5</td>
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<tr>
<td>Williams, 2002</td>
<td>111</td>
<td>25</td>
<td>100</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Meijer, et al., 2003</td>
<td>80</td>
<td>20-25</td>
<td>94</td>
<td>61</td>
<td>3</td>
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<tr>
<td>Sawamura, et al., 2003</td>
<td>101</td>
<td>40-50</td>
<td>91</td>
<td>71.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Seltch, et al., 2004</td>
<td>48</td>
<td>54</td>
<td>100</td>
<td>92.5</td>
<td>2.2</td>
</tr>
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</table>
RADIOSURGERY TECHNIQUE

Question: Is there a difference in outcome based on the dose delivered?

Recommendation: Level 3: As there is no difference in radiographic control using different doses, it is recommended that for single fraction SRS doses, <13 Gy be used to facilitate hearing preservation and minimize new onset or worsening of preexisting cranial nerve deficits.

Question: Is there a difference in outcome based on the number of fractions?

Recommendation: As there is no difference in radiographic control and clinical outcome using single or multiple fractions, no recommendations can be given.
GENERAL CONSIDERATIONS FOR SRS/ SRT
STEPS OF TREATMENT

• IMMobilization (Mask / Frame)
• MRI & CT Fusion
• Contouring of Target and OAR
• Planning:
  • Static Conformal
  • IMRS
  • Dynamic Arc
  • Hybrid
Frame/Mask Preparation
Image Fusion
ExacTrac images are fused to the digitally reconstructed radiograph from the treatment planning CT scan.
• **Benign tumours of brain have long latency and indolent history**

• **Surgery, whenever feasible should be considered**

• **Post operative radiotherapy is considered for incompletely resected, high grade, recurrent and inoperable lesions**

• **Conformal techniques like SRT is encouraged**

• **SRS is having excellent outcomes**

• **Technical and clinical learning curve of SRS is to be considered.**
THANKS