Accuracy, Conformality, and Radiation Dose Fall off for Brain SRS

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Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

SUBMILLIMETER ACCURACY?
Registration Principles

• Co-Registration: PET-CT

• Manual Registration: Point to Point

• Manual/Automatic Registration: Surface Matching

• Automatic Registration: Volumetric Shared data
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

**SUBMILLIMETER ACCURACY!**
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

“Application Accuracy”
R.J. Maciunas, 1994

The total clinically relevant error (application accuracy) comprises errors associated with each procedural step, including:

- imaging,
- target selection,
- vector calculations, and the
- mechanical errors.
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

Application Accuracy

- imaging
- target selection
- vector calculations
- mechanical errors
FACTORS INFLUENCING APPLICATION ACCURACY

- **Imaging modality**
  - **CT**: Spatially Accurate
  - **MRI**: Potential Magnetic Field Distortion, More Artefact Prone, Slower Acquisition
  - **fMRI**: Low Resolution
  - **MRS**: Low Resolution
  - **PET**: Low Resolution
FACTORS INFLUENCING APPLICATION ACCURACY

CT:
- Spiral Acquisition
- Slice thickness
- Gantry Angle (zero)

MRI:
- True Volumetric Sequences: SPGR (GE), MPRAGE (Siemens)
- Pseudo-volumetric acquisition: Thin slice, No Gap
- Plane of Acquisition
- Slice Thickness
MRI Standard Acquisition
MRI Volumetric Acquisition
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

Application Accuracy

- imaging
- target selection
- vector calculations
- mechanical errors
• Multi-modality planning
• (CT, CTA, MRI-different sequences, PET, other)
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

**Application Accuracy**

- target selection
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

Application Accuracy
- target selection
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

**Application Accuracy**

- imaging
- target selection
- vector calculations
- mechanical errors
Transformation Matrix

Physical Space

PET IMAGE SPACE

CT IMAGE SPACE

MRI IMAGE SPACE

Physical Space
• Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

Application Accuracy

- vector calculations
Registration Principles

- Solid Body Transformation
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
Image Registration
CLOSE TO HOME

COMPUTE-A-CUT
THE '90S WAY TO CUT HAIR

“Well, there’s your problem! You need to rotate your image 90 degrees counterclockwise, plus your trimming level is set way too low.”
Image Space to Physical Space Registration
Image Space to Physical Space Registration

- **Mechanical Accuracy of system**
- **Registration Accuracy**
- **Head Immobilization**
- **Verification of Head Immobilisation...How often?**
- **Correction for Movement**
Localization Error: “When Application Accuracy Goes Bad”
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

Application Accuracy
Conformality
Radiation Dose Fall Off

Conformal: Means preserving the angles at which curves cross each other
Conformality: Essentially how closely the target contour is followed
Conformality: How tight is the prescription isodose line

MLC

CONE
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

Application Accuracy
Conformality
Radiation Dose Fall Off
Radiation Dose Fall off: Penumbra

“Cone-based”....

Single...multiple....

Beam shaping: “Micromultileaf”
<table>
<thead>
<tr>
<th></th>
<th>Conformality (small target)</th>
<th>Dose Drop off (small target)</th>
<th>Dose Heterogeneity (hot spots)</th>
<th>Conformality (large target)</th>
<th>Dose Drop off (large target)</th>
<th>Dose Heterogeneity (hot spots)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cone isocentric</strong></td>
<td>+++</td>
<td>+++</td>
<td>(+)</td>
<td>+</td>
<td>(+)</td>
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<tr>
<td><strong>Cone non-isocentric</strong></td>
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<tr>
<td><strong>Micro-multileaf</strong></td>
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</tbody>
</table>
Radiation Dose Fall off: Cone vs. Micromultileaf

Cone

Micromultileaf
Three Key Factors in Brain Stereotactic Radiosurgery (SRS):

**Application Accuracy**  How accurate and when?

**Conformality**  How conformal and when?

**Radiation Dose Fall Off**  How steep and when?
"A fool with a tool is still a fool"

Lars Leksell