Single Isocenter Treatment of Multiple Cranial Targets

Disclosures

Industry Grant, Brainlab
Consultant, Brainlab
Member, Novalis Accreditation Expert Panel

Credits

Special Thanks To The Following Vendors

Brainlab, Varian
See Nuclear, Beauf, PTV
Mohan, Ashland, modusQA

Collaborators From Other Institutions:
Antonio Desalles, MD, PhD
Tamer Ghorab, PhD
Alessandra Carughi, MD
Paul Medin, PhD
Michael Steinberg, MD
Michael Selch, MD
Enhanced Dynamic Conformal Arcs vs. Volumetric Modulated Arc Therapy (VMAT)

New Simultaneous Radiosurgery vs. Old Multi Isocenter Treatments

- Improved Patient Experience - Significant reduction in treatment times: 20 mins vs. 2 hours
- Provider Benefits - One isocenter positioning and verification process: 5 mins vs. 45 mins
- Increased Throughput - Faster and efficient planning process: 30 mins vs. 2 hours

Patient Simulation to Contours Approved
Interventions, Improvements and Sustainability

Wait Time for Contours

- Intervention #1: February 2012 - Procedural Changes and Improved Assignment of Planning Personnel
- Intervention #2: October 2013 - Procedural Changes and Faster Availability of Images for Contouring
- Intervention #3: December 2015 - Procedural Changes and Improved Communication with Physicians
Treatment Planning Time (after approved contours)

Physicist Treatment Attendance Time (Personal supervision prior to Tx Start Time)
Commissioning and Validation

- PerFRACTION
- Gafchromic Quick Phantom
- MapCheck
- Film and Ion Chamber
- Eclipse
- ArcCheck
- RT Safe
- ModusQA
- Mobius3D
- MU Check

Multimets Calculation vs. Eclipse Calculation

Elements™ Multiple Brain Mets (Pencil Beam) vs. Eclipse (AAA)

- Planned with Elements (1.25mm adaptive grid size)
- Exported into Eclipse
- Recalculated with AAA (1.0mm, 2.0mm, 3.0mm grid size)
MultiMet Elements vs. AAA
Compared within Eclipse

Radiation treatment of the patient-specific dosimetry phantom - RT Safe
Radiation treatment of the patient-specific dosimetry phantom

Positioning the Calibration Tubes

Calibration Tubes Irradiated
Irradiation Process of the patient-specific dosimetry phantom – RT Safe
Irradiation Process of the patient-specific dosimetry phantom – RT Safe
Absolute Dose Calculation and Ion Chamber Measurements

Absolute Dose Calculation – Cavity Object Statistics
### Absolute Dose Calculations vs. Measurements Results

#### Cavity Stats vs. Measured

<table>
<thead>
<tr>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>Measured</th>
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<tr>
<td></td>
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<td>0.0%</td>
<td>1.7%</td>
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<tr>
<td></td>
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#### Absolute Dose Calculations vs. Measurements Results

**Max Dose in the ion chamber calculated by Elements**

**Min Dose in the ion chamber calculated by Elements**

**Mean Dose in the ion chamber calculated by Elements**

**Dose MEASURED with an ion chamber**
Three Target Plan Measurements with RT Safe Gel Phantom

**PART V: Dosimetric comparison**

Comparison between planned and measured relative dose distributions is presented in the following figures, in terms of cumulative Dose-Volume Histograms (DVHs) for all PTVs. All dose distributions were normalized to the corresponding Dmax metric (i.e., the maximum dose received by at least the 50% of the volume) of each structure.

The 0-12 Gy Gels provide accurate relative dose measurements in the 0-100% range.

The 3-35 Gy Gels provide accurate relative dose measurements in the ~10-100% range.

Some end users are interested in the DVHs of the healthy brain, requiring 0-12 Gy Gels.

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**Patient Specific QA Methods**

- **PerFRACTION**
- **Eclipse**
- **MapCheck**
- **Film and Ion Chamber**
- **MU Check**
- **Gafchromic Quick Phantom**
- **ArcCheck**
- **Fong Phantom**
Clinical Case 1 - Five Metastases - 18 y.o. male with osteoblastic osteosarcoma

<table>
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<tr>
<th>Metastasis</th>
<th>PTV</th>
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Multiple Mets Elements (Pencil Beam) vs. Eclipse (AAA)

MME vs. Eclipse AAA Calculations – Five Mets
Sun Nuclear - SunCHECK™ QA web platform

Secondary dose calculation
DoseCHECK
3D secondary dose calculation and analysis

Log File Based QA
3D dose reconstruction using the log file

EPID Based QA
3D Pre-Treatment QA with EPID measurements

PerFraction Secondary Calculation (DoseCHECK) for Brain Metastases - Five Mets
Ion Chamber Measurement

Mean Calculated Dose vs. Ion Chamber Measurement

Ion Chamber Measurements for Brain Metastases – Five Mets

<table>
<thead>
<tr>
<th>Clip Name</th>
<th>Clip Type</th>
<th>Dose (cGy)</th>
<th>Tissue (cm)</th>
<th>Prescribed Dose (cGy)</th>
<th>Prescribed Volume (%)</th>
<th>Volume (%)</th>
<th>Date (mm/dd/yy)</th>
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Film Measurements for Brain Metastases – Five Mets

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Clinical Case 2 – Seven Metastases - Conical Collimator 12 Gy to the Brainstem Target

Clinical Case 2 – SBRT 6Gy x 5

Clinical Case 2 – SBRT 6Gy x 5 to the Smaller Lesion Next to the Large Met
Clinical Case 2 – MultiMet Targets – 18Gy to Other Four Metastases

All Targets Planned in MME (Except Cone)

Composite Planning in Elements Strategy

Four small tumors 18Gy x 1
Large tumor 6 Gy x 1
Large tumor 6 Gy x 4
Composite Planning in Elements: Selection of Table Positions

MME vs. Eclipse AAA Calculations - Four Mets

PerFraction Secondary Calculation (Dosetch) for Brain Metastases - Four Mets
Clinical Case 3 - Seven Metastases

- Inclusion of the Superior target: Will increase the intertarget-target
discrepancy. Rotational misalignments will become dosimetrically more
significant.
- Ticker MLC leaf pairs will be used for Treatment.
- Target may fall outside of irradiation area.
Clinical Case 3 - All Targets Planned in Multiple Mets Element

18Gy x 1 target is well isolated from others

Contiguous V12 < 10cc (includes the GTV volume)

MME produces:
- More inhomogeneous distribution
- Larger volume of irradiation because of the margins used

Clinical Case 3 - Seven Metastases

Composite Planning in Elements Multiple Brain Mets SRS

Remote lesion treated with its own separate isocenter and arcs using smaller leaves
Improving Dosimetry with Separate Isocenter and Arcs

Elements Multiple Brain Mets SRS
5 mm leaves

Elements Multiple Brain Mets SRS
2.5 mm leaves

Elements Cranial SRS
2.5 mm leaves
Tolerances – 0.5 mm and 0.5 degrees
Margins – 1 mm or 2 mm based on the distances from the isocenter
Consider two isocenter treatments for multiple targets that are distributed or clusters

Offset (mm) as a Function of Distance from Isocenter (mm) and Rotational Deviation (degrees)

Intrafraction Motion of MME Patients - Frequency of Repositioning
Intrafraction Motion of MME Patients - Translations - 12 Patients and 74 Targets

Intrafraction Motion of MME Patients - Rotations - 12 Patients and 74 Targets

V5, V10, V12 Values vs. Margins Used for Treatment Planning

<table>
<thead>
<tr>
<th>Cumulative TV = 3.2 cc</th>
<th>Cumulative TV = 1.4 cc</th>
<th>Cumulative TV = 0.5 cc</th>
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<tbody>
<tr>
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<td>V5 &gt; 60.6 cc</td>
<td>V5 &gt; 50.3 cc</td>
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<tr>
<td>V10 &gt; 36.8 cc</td>
<td>V10 &gt; 26.6 cc</td>
<td>V10 &gt; 18.0 cc</td>
</tr>
<tr>
<td>V12 &gt; 22.5 cc</td>
<td>V12 &gt; 13.6 cc</td>
<td>V12 &gt; 10.8 cc</td>
</tr>
<tr>
<td>0 mm margin</td>
<td>1 mm margin</td>
<td>2 mm margin</td>
</tr>
</tbody>
</table>
Histogram of Target Distances from Isocenters

Histogram of Target Distances from Isocenters

Histogram of Total Target Volume vs Margin

Average V5, V10, V30, V50 Values - 8 patients with 51 Targets

Variable Margins for Targets <6cm and >6cm from Isocenter
Depending on Clinical Prescription Strategy
10-15% of Targets May Get Lower Prescription
Variable Margins for Targets <6cm and >6cm From Isocenter

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Patient Specific QA and IGRT Requirements
For Single Isocenter Treatment of Multiple Cranial Targets