Evaluation of Lung Heterogeneity
Corrections for Clinical Trials Using
the RPC Lung Phantom

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RPC Lung Phantom

Target dimension

- Ovoid shape
- 3 cm diameter / 5 cm long

Densities

- Lung = 0.33 g/cm³
- Heart, cord = 1.1 g/cm³
- Cord = 1.31 g/cm³
- Tumor = 1.04 g/cm³
RPC Phantom

Dosimeters
  TLD
Gafchromic film

Disassembled Lung Insert
Phantom Process

- Phantom is imaged
- Treatment plan developed by institution per instructions
- Treatment is delivered to the phantom
- Phantom is returned to the RPC for data analysis
- Treatment plan is submitted electronically to the ITC for review by RPC staff
Criteria for Acceptability

- **Dose criteria:**
  \[ \frac{D_{\text{TLD}}}{D_{\text{Inst}}} \text{ between } 0.92 - 1.02 \]

- **1D Profile analysis:**
  \[ \text{DTA} \leq 5\text{mm} \text{ in high gradient region by the target} \]

Criteria based on first group of institutions irradiating the phantom
Profile Analysis

Film

TPS data
Profile Analysis

Right Left Profile

Left
Average displacement
Left side: 3 mm

Righ
Average displacement
Right side: 1 mm

Dose (Gy)
Distance (cm)

PTV

-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7
-7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7

RPC Film
Institution values
RPC Regression
Institution Regression
Profile Analysis

Right Left Profile

Left

Average displacement
Left side: -2 mm

Right

Average displacement
Right side: -4 mm

Dose (Gy)

Distance (cm)

PTV

Acceptable by previous criteria
Phantom Results

- A total of 45 “approved” lung irradiations were reanalyzed.

- The TPSs used to plan the 45 cases included:
  - BrainLab
  - Precise
  - Eclipse (AAA/PB)
  - Pinnacle (CC Convolution/Adaptive Convolve)
  - XiO (Superposition/Fast Superposition)
  - Hi-Art
2D Gamma Index Analysis

Film

TPS data
2D Analysis Gamma Index

Axial
Fail = 0.29%
Pass = 99.71%

Coronal
Fail = 8.15%
Pass = 91.85%

Sagittal
Fail = 4.86%
Pass = 95.14%

Sagittal Gamma 2D

DTA = 5 mm
Dose Diff = 5 %
Ref Dose = 7.371 GY
Pass = 95.14%  Fail = 4.86%
Pass < 1  Fail > 1

Gamma above 2 is mapped to 2
2D Analysis - Eclipse Case AAA vs. PB

AAA

PB

Fail = 0.29%
Pass = 99.71%

Pass = 60.68%
Fail = 39.42%

DTA = 6 mm
Dose Diff = 5 %
Ref Dose = 7.371 GY
Pass < 1  Fail > 1
Pass < 1  Fail > 1
# Phantom Analysis

<table>
<thead>
<tr>
<th>TPS</th>
<th>Dose Calc. Algorithm</th>
<th># irradiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BrainLab</td>
<td>Clarkson &amp; Pencil beam</td>
<td>2</td>
</tr>
<tr>
<td>Precise</td>
<td>Scatter Int. Clarkson</td>
<td>2</td>
</tr>
<tr>
<td>Eclipse</td>
<td>Pencil Beam</td>
<td>11</td>
</tr>
<tr>
<td>Eclipse</td>
<td>AAA</td>
<td>11</td>
</tr>
<tr>
<td>Pinnacle</td>
<td>Adaptive convolve / CC Convolution</td>
<td>14</td>
</tr>
<tr>
<td>XiO</td>
<td>Superposition/Fast Superposition</td>
<td>6</td>
</tr>
<tr>
<td>Hi-Art</td>
<td>Superposition Convolution</td>
<td>1</td>
</tr>
</tbody>
</table>
## 2D Analysis Results – Axial Plane

<table>
<thead>
<tr>
<th>Dose Calc. Algorithm</th>
<th># cases</th>
<th>$D_{TLD}$</th>
<th>Axial</th>
<th>Coronal</th>
<th>Sagittal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarkson-PB</td>
<td>15</td>
<td>0.96 ± 3%</td>
<td>84% ± 16%</td>
<td>73% ± 20%</td>
<td>67% ± 24%</td>
</tr>
<tr>
<td>SC-AAA</td>
<td>30</td>
<td>0.97 ± 3%</td>
<td>99% ± 4%</td>
<td>88% ± 6%</td>
<td>92% ± 7%</td>
</tr>
</tbody>
</table>
Conclusions

The Convolution Superposition / AAA algorithm calculations show better agreement in dose distribution over the PTV compare to pencil beam or Clarkson cases.

Next step is to extend the area of analysis to include area irradiated to 20% of prescribed dose or higher which will include more points within the lung itself.

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Thank you