Evaluation Criteria for IROC’s Proton Prostate Phantom

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IROC’s Mission

Provide quality control programs in support of the NCI’s National Clinical Trial Network thereby assuring high quality data for clinical trials
Proton Phantom Audits

- Brain
- H&N
- Liver
- Lung/thorax
- Prostate/pelvis
- Spine
Proton Prostate Phantom Design

- Target: Prostate
- OARs: Bladder, rectum, and femoral heads
- Dosimetry insert contains TLD and radiochromic film for absolute and relative dose comparison with TPS
# Proton Phantom Audit Results

<table>
<thead>
<tr>
<th></th>
<th>Brain</th>
<th>H&amp;N</th>
<th>Liver</th>
<th>Lung</th>
<th>Prostate</th>
<th>Spine</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Irradiations</td>
<td>34</td>
<td>20</td>
<td>27</td>
<td>59</td>
<td>45</td>
<td>30</td>
<td>215</td>
</tr>
<tr>
<td># Passed</td>
<td>33</td>
<td>18</td>
<td>10</td>
<td>40</td>
<td>37</td>
<td>23</td>
<td>161</td>
</tr>
<tr>
<td>Pass Rate [%]</td>
<td>97%</td>
<td>90%</td>
<td>37%</td>
<td>68%</td>
<td>82%</td>
<td>77%</td>
<td>75%</td>
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</tbody>
</table>
Phantom TLD vs. Proton TPS

Results From Technological Advances

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Fig. 2. Ratio of the TLD-measured dose to the dose predicted by the treatment planning system for each phantom type. Abbreviation: TLD = thermoluminescent dosimeters.

pre-2015 data
Prostate PTV TLD

2015: Started to see an upward shift in TLD doses to target

Nothing changed in TLD system – we suspect a change in how dose is calculated in proton TPSs
Proton Dose Calculations Evolving

<table>
<thead>
<tr>
<th></th>
<th>2009 - 2014</th>
<th>2015 - 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>0.961</td>
<td>0.992</td>
</tr>
<tr>
<td>stdev</td>
<td>0.024</td>
<td>0.024</td>
</tr>
<tr>
<td>max</td>
<td>1.03</td>
<td>1.05</td>
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<tr>
<td>min</td>
<td>0.93</td>
<td>0.95</td>
</tr>
<tr>
<td># phantoms</td>
<td>27</td>
<td>16</td>
</tr>
</tbody>
</table>

- Eclipse aperture scatter for passive scattering
- Pinnacle’s angular scattering: sequential piecewise modeling
- RayStation “19-fold multi tracing per spot and separate handling of the nuclear halo effect”*
- Monte Carlo more accurately modeling multiple coulomb scattering

*https://www.raysearchlabs.com/radiation-therapy-physics/
PB Algorithms vs. MC in Proton Therapy

Assessing the Clinical Impact of Approximations in Analytical Dose Calculations for Proton Therapy

Jan Schuemann, PhD, Drosoula Giantsoudi, PhD, Clemens Grassberger, PhD, Maryam Moteabbed, PhD, Chul Hee Min, PhD, and Harald Paganetti, PhD
Proton Lung Phantom Dose Accuracy

• BIG improvements with Monte Carlo over pencil beam algorithms
What’s Next?

• New prostate phantom criteria set: 1.00 ± 7%
• Big improvements seen with Monte Carlo but not all MC appears equal
  – Working with proton centers to look at different MC algorithms
    • RayStation, Eclipse AcurosPT, TOPAS, MCSquare
• Investigating proton algorithm accuracy in H&N and liver
  – H&N: High density (bone) and low density (nasal passages, oral cavity)
  – Liver: Low phantom pass rate, low average TLD/TPS
  – Will we see the same improvements over time?
Questions?
Phantom Audits

- Phantoms made from proton-equivalent plastics