Implementation of Quality Assurance Program for CyberKnife Treatment Planning System

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Introduction

• Treatment planning system (TPS) is an integral part of radiation therapy (RT).

• Errors in commissioning of TPS could impact many patients.

• Nearly one third of the serious incidents in RT involve TPS (ICRP 86).

• The major standards for TPS commissioning and QA over the last two decades: AAPM TG 53 and MPPG 5.a.

• Presented here necessary tests for implementing a QA program for CK dedicated TPS in accordance with MPPG 5.a.
I. Basic dose algorithm validation
I.A. Basic field configurations (Fixed and Iris collimators).
I.B. Small MLC-shaped fields and large MLC-shaped field with extensive blocking
I.C. MLC special field blocking: spine block, corner block, convex, concave
I.D. Oblique incidence

II. Heterogeneity correction validation
II.A. Heterogeneity corrections distal to bone tissue
II.B. Heterogeneity corrections distal to lung tissue

III. IMRT Validation
III.A. Small field PDD verification, verification of output for small MLC-defined fields
III.B. TG-119 tests: C shape easy, C-shape hard, C-shape RA, Head and Neck
III.C. Clinical Tests: prostate, SBRT lung, Head and Neck and Lung standard fractionation
III.D. E2E cases, scanning an phantom, planning, delivery, and sending dosimeters out for external review
### Basic photon beam configuration

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Objective</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Basic_Field.1.</td>
<td>FC and IRIS</td>
<td>7.5 mm, 30 mm, 60 mm</td>
</tr>
<tr>
<td>Test Basic_Field.2.</td>
<td>Small and large MLC-shaped field</td>
<td>25x25 mm2, 100x100 mm2, 100x115 mm2</td>
</tr>
<tr>
<td>Test Basic_Field.3.</td>
<td>Extensive blocking MLC-shaped field</td>
<td>25x100, 100x25 mm</td>
</tr>
<tr>
<td>Test Basic_Field.4.</td>
<td>MLC special field blocking</td>
<td>Spine Block, Corner Block, Convex, Concave</td>
</tr>
<tr>
<td>Test Basic_Field.5</td>
<td>Oblique Incidence</td>
<td>30-degree oblique angle phantom</td>
</tr>
</tbody>
</table>
Analysis of PDDs and Profiles

• Axial Planar doses - RIT113 (DICOM RT Import files)
• Beam measurement tools: depth profile (PDDs) and cross profile (at Dmax)
• Dose calculation box was not modified between TPS1 and TPS2 calculations
Oblique Incidence
Heterogeneity correction validation
IMRT validation

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<tr>
<td>Test IMRT.1</td>
<td>Verification Small field PDD*</td>
<td>MLC-shaped field 7.6x7.5mm²</td>
</tr>
<tr>
<td>Test IMRT.2</td>
<td>TG-119 tests</td>
<td>Head and Neck and C-shape cases</td>
</tr>
<tr>
<td>Test IMRT.3</td>
<td>Clinical test</td>
<td>Brain, Spine, Lung and Abdomen</td>
</tr>
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TG 119 C-shape

TG 119 H&N
## Patient specific QA

<table>
<thead>
<tr>
<th>Tests</th>
<th>Algorithm</th>
<th>Comparison</th>
<th>Diff/Dist. Threshold</th>
<th>Passed Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test IMRT.2. C-shape</td>
<td>FSPB</td>
<td>TPS1 vs TPS2</td>
<td>1%/1mm, 10%</td>
<td>100%</td>
</tr>
<tr>
<td>Test IMRT.2. H&amp;N</td>
<td>FSPB</td>
<td>TPS1 vs TPS2</td>
<td>1%/1mm, 10%</td>
<td>100%</td>
</tr>
<tr>
<td>Test IMRT.3. Brain</td>
<td>FSPB</td>
<td>TPS2 vs Measured</td>
<td>2%/2mm, 10%</td>
<td>100%</td>
</tr>
<tr>
<td>Test IMRT.3. Spine</td>
<td>FSPB</td>
<td>TPS2 vs Measured</td>
<td>2%/2mm, 10%</td>
<td>100%</td>
</tr>
<tr>
<td>Test IMRT.3. Abdomen</td>
<td>FSPB</td>
<td>TPS2 vs measured</td>
<td>2%/2mm, 10%</td>
<td>100%</td>
</tr>
<tr>
<td>Test IMRT.3. Lung</td>
<td>MC</td>
<td>TPS2 vs measured</td>
<td>2%/2mm, 10%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Head and Neck, TPS1 vs TPS2**
Conclusions

- Implementation of MPPG 5a tests into CK TPS was successful.

- Differences in PDDs and profiles were minimal <1%, except for oblique incidence (up to 4%)

- Created set of tests will be used for subsequent TPS upgrades, as well as routine TPS QA at our center

- This work could serve as seminal benchmark for TPS commissioning and QA of CK TPS
Monte Carlo Commissioning for CyberKnife Multileaf Collimator and Proposed Acceptance Criteria

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THANK YOU!

QUESTIONS?
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