Implementing a Clinical Practice Guideline; Lessons From An Early Adopter of MPPG 5.a
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Disclosures
None
Outline

1. General experience with the implementation of MPPG 5.a
2. Benefits of implementation
3. Difficulties encountered during implementation
4. Development of organization and analysis tools
5. Availability of tools to the physics community

A Quick Show of Hands

- How many of you are familiar with Medical Physics Practice Guidelines?
- How many of you have put one into practice in your clinic?

What is MPPG 5.a?

- MPPG 5.a seeks to provide guidance on commissioning and validation of radiotherapy dose calculations for photons and electrons
  1. Identify applicable AAPM reports and published literature
  2. Provide updated guidance on technologies that are newer
  3. Provide guidance on validation tests for dosimetric accuracy
  4. Provide guidance on tolerance values and evaluation criteria for clinical acceptability
  5. Provide a checklist for commissioning
What is MPPG 5.a?

- Acquiring data and modeling
- Validation
- Documentation

COMMISSIONING A DOSE
CALCULATION MODEL

So you’ve downloaded MPPG 5.a...

Now what?

What is MPPG 5.a asking of me?

- Read it to identify all of the things I need to do:
  - Sections 1-4: Guidance on the beam data acquisition and modeling process
  - Sections 5–8: Guidance on beam model validation
  - Sections 9–10: Wrapping it up
MPPG 5.a Validation: Big Picture

**What tools do I need?**

<table>
<thead>
<tr>
<th>Test Number</th>
<th>Test Description</th>
<th>Measurement Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Physics module versus planning module</td>
<td>None</td>
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<tr>
<td>5.2</td>
<td>Clinical calibration geometry</td>
<td>Scanning water tank; Farmer-type ionization chambers</td>
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<td>5.3</td>
<td>Planning module dose versus commissioning data</td>
<td>Scanning water tank; scanning ionization chambers</td>
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<td>5.4-5.8</td>
<td>Basic photon beam tests</td>
<td>Scanning water tank; scanning ionization chambers</td>
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<td>5.9</td>
<td>Non-physical wedge test</td>
<td>MapCHECK2</td>
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<td>6.1</td>
<td>CT-value to density calibration</td>
<td>Electron density phantom</td>
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<tr>
<td>6.2</td>
<td>Heterogeneity correction</td>
<td>Custom phantom; ionization chamber</td>
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<tr>
<td>7.1</td>
<td>Small field PDD</td>
<td>Scanning water tank; diode detector</td>
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<td>7.2-7.4</td>
<td>TG-119 and clinical tests</td>
<td>Delta4; MapCHECK2</td>
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<td>7.5</td>
<td>External review</td>
<td>Radiochromic film; OSLDs</td>
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<tr>
<td>8.1</td>
<td>Basic electron fields and obliquity tests</td>
<td>Scanning water tank; scanning ionization chambers</td>
</tr>
<tr>
<td>8.2</td>
<td>Electron heterogeneity correction</td>
<td>Custom phantom; ionization chamber</td>
</tr>
</tbody>
</table>

**1. Gathering the Phantoms**

- Water Phantom
- Heterogeneous Phantom
- Patient CT
2. Calculating Treatment Plans

3. Making Measurements

4. Comparing Measured and Calculated Dose
5. Is my model good enough yet?

MPPG 5.a proposes a set of minimum tolerances and evaluation criteria for each test:

- **Minimum Tolerances**
  - Widely accepted tolerances based on published guidelines, IROC dosimetry audits, and other published results.
  - Considered a minimum standard, not a recommended stopping point for model improvement.

- **Evaluation Criteria**
  - Given where no widely accepted tolerances are available.
  - Designed to emphasize areas of disagreement and highlight opportunities for further investigation and improvement.

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**Minimum Tolerances**

5. Reference calibration geometry (0.5%)
   - High dose (2% local)
   - Penumbra (3 mm)
   - Low-dose tail (3% global)

6. Dose above and below heterogeneity in regions of CPE (3% local on CAX)

7. Ion chamber in low-gradient target (2% of Rx)
   - Ion chamber in OAR region (3% of Rx)
   - Film or array-based IMRT/VMAT QA (2%/2mm)
   - End-to-end test (5%)

8. High-dose/low-gradient regions in water (3%)
   - PDDs in water (3%/3mm)
   - Oblique incidence in water (5% on CAX)
   - Heterogeneity correction (5% on CAX)

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**Application of Minimum Tolerances**

- High dose (2% local)
- Penumbra (3 mm)
- Low-dose tail (3% global)

MPPG Test 5.7
Application of Evaluation Criteria

MPPG Test 7.4: 3%G/3mm

Why Recommend 2%/2mm?

- A stricter evaluation criteria can:
  - Identify easily correctable modeling errors
  - Highlight weaknesses in a dose calculation algorithm
  - Are more sensitive to changes in beam model parameters
Overall Experience

- MPPG 5.a is a do-able, well-organized approach to dose calculation validation
- Dose calculation algorithms in Pinnacle, Eclipse and Mobius3D are capable of meeting the tolerances specified in MPPG 5.a for both Elekta and Varian linacs
- Total time commitment is ~79 hours
  - 26 hours involve time on the machine and the remainder is preparation and analysis
  - Approximately half of the time involves preparing, measuring and analyzing IMRT and VMAT plans

Benefits of MPPG 5.a

1. The dataset needs to be measured once per machine, but the analysis can be repeated again and again on new dose calculation algorithms.
2. The wide variety of tests in MPPG 5.a can probe your model and finds real weaknesses.
3. The built-in end-to-end testing verifies the full clinical workflow.

Versatility of the Validation Dataset

- Medical University of South Carolina
  - Eclipse TPS commissioning for two TrueBeams
  - Mobius3D commissioning for two TrueBeams
  - Eclipse TPS upgrade
- Beloit Memorial Hospital
  - Pinnacle TPS upgrade
  - Mobius3D commissioning for Elekta Infinity
- University of Wisconsin Hospital
  - Pinnacle TPS commissioning for one TrueBeam
Versatility of the Validation Dataset

• The MPPG 5.a validation data will come to define your treatment unit:
  • Define the scope of future model validation, saving you the overhead of planning what to test
  • Serves as a benchmark for comparing different algorithms
  • A model that agrees well with this data is clinically acceptable

Finding Real Weaknesses

• Every model has its weak points:
  • Eclipse Acruos struggles with out-of-field dose, particularly at deeper depths

Finding Real Weaknesses

• Every model has its weak points:
  • Older versions of Mobius3D did not have a leaf-offset table
Finding Real Weaknesses

- Every model has its weak points:
  - Pinnacle's "Electron 3D" model is difficult to tune over a full range of profile depths

Built-in End-to-end Testing

- Every step of the planning and delivery process is tested by MPPG 5.a
  - Simulation and image import
  - Beam generation and dose calculation
  - Export to OIS
  - Generation and measurement of QA plans
  - Image guidance and treatment

Difficulties with MPPG 5.a

- Difficulties encountered during MPPG 5.a
  - Deciding how difficult to make a test
  - Applying tolerances and evaluation criteria
  - Basic electron output check test is missing
  - Order of the testing is somewhat confusing
Difficulties with MPPG 5.a

• Deciding how difficult to make a test

Difficulties with MPPG 5.a

• Applying the tolerance criteria

Difficulties with MPPG 5.a

• Basic electron output check test is missing
Difficulties with MPPG 5.a

• Order of testing is somewhat confusing

Development of Organization and Analysis Tools for MPPG 5.a

• Automated Profile Comparison Tool
  • Overview
  • Measured Data
  • Dose Calculation Data
  • Analysis Options
  • Analysis Summary
• DICOM Renamer
• Organizational Spreadsheet

The Profile Comparison Tool

• The MPPG #5 Profile Comparison Tool (PCT) is a simple but powerful profile comparison tool designed to be used during the commissioning and QA of external beam treatment planning systems.
• The program accepts profile data from scanning water tank systems and DICOM-RT DOSE files from commercial treatment planning system, co-registers the data sets, and performs a 1D gamma analysis on the profiles.
• The user may specify a number of analysis and export settings.
Overview

Measured Data

- Accepts exported data from scanning software:
  - W2CAD (Eclipse TPS import)
  - OmniPro ASCII
  - PCT automatically determines profile type

Dose Calculation Data

- Accepts exported DICOM-RT DOSE files from TPS
- Available from all commercially available TPS
- PCT automatically extracts the PDDs and profiles from 3D dose distribution
Co-registration of Datasets

- PCT can automatically co-register the measured and calculated data

Analysis Options

- Normalization options for PDD and profiles
- Gamma analysis options
- Dose difference, DTA and global/local comparisons

Analysis Summary

- PDF of PDDs and profiles
- Summary Spreadsheet
Analysis Summary

DICOM-RT File Renaming Tool
- Automatically identifies and renames DICOM-RT plan, dose and structure set files that are from the same plan

Organizational Spreadsheet
Availability of Tools to the Physics Community

GitHub (most up-to-date)
- https://github.com/Open-Source-Medical-Devices/MPPG
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Questions?
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