QA Dosimetry for IMRT Prostate Treatments

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Why QA?

- IMRT – Needs high precision and accuracy.
- Reduces the uncertainties and errors
- Improving dosimetric and geometric accuracy and precision of dose delivery.
- Likelihood of accidents and errors occurring, it also
- Increases the probability that they will be recognized and rectified sooner
- Inter-comparison of results among different radiotherapy centers
- Ensuring a more uniform and accurate dosimetry and treatment delivery.
‘Chain’ of IMRT Process

- Positioning and Immobilization
- Image Acquisition
- Structure Segmentation
- IMRT Treatment Planning and Evaluation
- File Transfer and Management
- Position Verification
- IMRT Treatment Delivery and Verification
- Plan Validation

Adapted from an illustration presented by Webb and ASTRO/AAPM Scope of IMRT Practice Report
IMRT QA

Two types of QA

System related

- Accuracy of delivery system
- Treatment planning system data integrity
- Various test to be added to periodic QA

Patient Specific

- Check of plan parameters
- Independent check of planned dose calculation
Machine QA for IMRT

- Many segments with small MUs
  - Dose linearity @ low MUs
  - Startup characteristics (flatness & symmetry)
  - Know the limitations of your machine – set limits on minimum MUs for planning
Machine QA for IMRT

- Many small segments, often asymmetric
  - Output factors sensitive to small changes in size
  - Know the limitations of your dose calculation – set limits on minimum segment size for planning
- MLC positional accuracy at off axis
Patient Specific QA

- Point dose measurement
- Evaluation of Fluence map generated by the TPS
- Leaf positioning Check (BEV)
IMRT QA WORK FLOW

CT scan phantom, plan with patient beams, calculate doses

Treat phantom, perform film dosimetry, get doses, compare to calculation
Dose Verification Procedure (Prostate Example)

- Phantom positioned on the simulator couch ready to be scanned
- It is important to choose a phantom with a versatile design that allows for many configurations to simulate individual treatment plans
Dose Verification Procedure

Three view scan of the phantom in the treatment planning system
Dose Verification Procedure

- The three view treatment plan is transposed onto the phantom scan
- RTPS applies the planned fluence on a solid water phantom at a known depth
- Computes the dose at that depth and generates a dose map file
Dose Verification Procedure

- Phantom on accelerator treatment couch ready for treatment
- Treat the phantom and measure the doses
  - Ion-chambers, Films, MOSFET dosimeter
  - Compare the doses generated by the TPS
- Chamber is at isocenter
- Diodes are offset, left and right of the chamber
- Expose a film – Convert OD to dose
- Compare with dose map generated by RTPS
Dose Verification-Analysis

Examine the fluence dose image of a film placed between acrylic slabs of the IMRT Phantom
Evaluation & Comparison of Calculated and Measured values:

1. Iso-line compare
2. Profile compare & its difference in all planes.
3. Dose difference.
4. Distance to Agreement (DTA).
5. Gamma Method
Iso-line compare

Plain Field 1

Plain Field 3
Profile Comparison Analysis

Analysis of a vertical fluence dose profile of the measured film versus the calculated dose on the radiation treatment plan with position.
Profile Comparison Analysis

Analysis of a horizontal fluence dose profile of the measured film versus the calculated dose on the radiation treatment plan with position
A dose-difference distribution can be displayed and identifies the regions where the calculated dose distributions disagree with measurement.

In high dose gradient regions, a small spatial error, either in the calculation or the measurement, results in a large dose difference between measurement and calculation.
Distance to Agreement (DTA)

- Dose difference in high dose gradient may therefore be relatively unimportant,
- Concept of a Distance-to-Agreement distribution is used to determine the acceptability of the dose calculation.
- The DTA is the distance between a measured data point and the nearest point in the calculated dose distribution that exhibits the same dose.
The dose-difference and DTA evaluations complement each other when used as determinants of dose distribution calculation quality.

Gamma method uses a passfail criterion of both the dose difference and DTA.

Each measured point is evaluated to determine if both the dose difference and DTA exceed the selected tolerances (e.g. 3% and 3 mm, respectively)
Gamma Method
**PATIENT SPECIFIC ABSOLUTE DOSE MEASUREMENT**

**BEAM DOSE MEASUREMENT**

Date: 28/07/2007

<table>
<thead>
<tr>
<th>Beam No.</th>
<th>M.U.</th>
<th>Meter Reading</th>
<th>Dose (cGy)</th>
<th>Variation in Dose cGy</th>
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<tr>
<td></td>
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<td>R1  R2  R3  Avg.</td>
<td>Mes.  TPS</td>
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<tr>
<td>1(15%)</td>
<td>118</td>
<td>117.1 117.1 117.1 117.1</td>
<td>116.5 116  +0.5</td>
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<td>2(15%)</td>
<td>12</td>
<td>115.0 115.0 115.0 115.0</td>
<td>114.4 113  +1.4</td>
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<tr>
<td>3(16%)</td>
<td>108</td>
<td>117 117 117 117</td>
<td>116.41 116  +0.41</td>
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<tr>
<td>4(16%)</td>
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<td>111.3 113 113 113</td>
<td>112.4 112.5 -0.1</td>
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<tr>
<td>5(16%)</td>
<td>115</td>
<td>119 119 119 119</td>
<td>118.4 116.9 +1.5</td>
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<tr>
<td>6(16%)</td>
<td>11</td>
<td>124 124 124 124</td>
<td>123.4 123  +0.4</td>
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<tr>
<td>7(16%)</td>
<td>113</td>
<td>114.4 114.4 114.4 114.4</td>
<td>113.8 113.6 +0.2</td>
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<tr>
<td>8(16%)</td>
<td>12</td>
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<tr>
<td>9(16%)</td>
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</tr>
<tr>
<td>14(14%)</td>
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Measurement at a depth of 10 cm of perspex
Average difference in dose is 0.616 cGy

**TOLERANCE ≤ 2cGy OR ≤ 3%**
If DTA passes at 3%/3mm level proceed with the treatment.

At the 5%/5mm level examine sources of discrepancies. Proceed with treatment only if
- Discrepancies can be resolved or
- Region of error are clinically insignificant

Beyond 5%/5 mm, Perform the measurement
Acceptable limited is less than 2 mm

At HCG ~ 200 fields checked and found less than 2 mm
LEAF POSITIONING & ISOCENTRE CHECK (DRR vs PORT FILM)

TOLERANCE : 5mm
What to Do With Errors Detected?

- ALWAYS correct gross errors!
- Small errors need to be studied to find out if they are random (treatment errors), or systematic errors (planning errors)
- Image first 3 days of treatment, correct systematic error if greater than tolerance,
- then image once per week
“A Practical Guide to Intensity Modulated radiation Therapy”,
Medical physics Publishing and Memorial Sloan Cancer center, 2003

“Intensity Modulated Radiation therapy, The state of the art”
Palta, J.R., Mackie, T.R., eds.,
AAPM monograph 29, 2003