Patient Specific Quality Assurance in IMRT

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What are Differences in Patient Specific QA Between 3D-CRT and IMRT?

Outline

- Patient Setup
- Patient Immobilization
- Treatment Planning
- Treatment Verification
- Dose Verifications

Patient Setup and Immobilization
- Setup patient in a comfortable position.
- Immobilize patient well.
- Carefully screen patients for suitability of IMRT treatment.

Patient Setup
Comfortable patient positioning
Index Patient Positioning

More Beam Accessibility

Patient Selection

- Weekly conference to discuss potential patients for IMRT treatment, based on available machine time and man-powers.
- Compare conventional 3D plans with IMRT plans for justification of applying IMRT in new treatment sites.
- Patients who can not sustain prolonged treatment time are not qualified for IMRT.

Three Sets of Orthogonal Films

Three Sets of Orthogonal Films

0 Minutes 15 Minutes later 30 Minutes later

How Much Patient Moved?

- 16 patients were participated in this study.
- Taking orthogonal portal films prior to and after treatment for the first three days.
- These portal films are digitized and analyzed by a physician and a physicist.

Patient Movement

Figure 1

- $x$-direction
- $y$-direction
- $z$-direction

Patient Movements (mm)

Orthogonal Portal Film Set Number
**Treatment Planning**

**Target and Structure Delineations**
- Only treat contoured targets
- Only spare contoured structures: Spinal Cord, Brain stem, Optical structures, Parotid glands, Mandible, Tongue, TMJs, Larynx, Ears, Neck skin, artificial structures if needed.

**Plan Acceptance Criteria**
- RTOG Protocols (www.rtog.org)
  - H0022 - T1-2 Oropharyngeal Cancer
  - H0225 – T1-4 Nasopharyngeal Cancer
- Establish local standard for each disease site by periodically reviewing approved plans.

<table>
<thead>
<tr>
<th>Structures</th>
<th>Mean Dose (Gy)</th>
<th>Dose to 50% Vol. (Gy)</th>
<th>Dose to 80% Vol. (Gy)</th>
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<tbody>
<tr>
<td>Chiasm</td>
<td>27.5</td>
<td>21.5</td>
<td>19.7</td>
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<td>Spinal Cord</td>
<td>38.3</td>
<td>30.6</td>
<td>25.8</td>
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<td>Brain Stem</td>
<td>50.9</td>
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<td>Optic Nerve Eye</td>
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<td>17.9</td>
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<tr>
<td>T-M joint</td>
<td>33.8</td>
<td>30.5</td>
<td>26.7</td>
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<tr>
<td>Mid./Inner Ear</td>
<td>41.4</td>
<td>38.3</td>
<td>31.3</td>
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**T3-4 Nasopharyngeal Cancer**

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<td>33.0</td>
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<td>43.1</td>
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<td>38</td>
<td>36.7</td>
<td>31.5</td>
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<tr>
<td>Middle/Inner Ear</td>
<td>49.6</td>
<td>49.8</td>
<td>42.2</td>
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Treatment Verification

Verification

- Iso-center verification - Orthogonal films
- Check intensity pattern prior or during treatment
  - Use portal film with reduced dose.
  - Use new extended dose range film (EDR2) tapped in a reticule.
  - Use Computed Radiography (CR).
- Check delivered MU/field vs planned MU

Intensity Pattern Check

Intensity Map

Port Film

What is Computed Radiography?

- A digital replacement for x-ray film and film processors
  - film → phosphor screen
  - cassette → cassette
  - processor → scanner

Computed Radiography System
Dose Verification

Dosimetric QA
- Delivery a patient-specific phantom plan is a good dry run to test connectivity of the entire IMRT procedure from planning to delivery.
- Identify undeliverable beams, potential collisions and obstructions in the beam.
- Verify entire plan, not single beam, including the same beam geometry as in the patient plan.
- It is difficult to find a uniform dose region within a single beam, especially for complex H&N plans.
Useful Tools

- Phantoms (Various sizes)
- Small ion chamber – (CC-13, Wellhoffer, 0.13 cc active volume).
- Electrometer
- TLDs (TLD reader)
- EDR2 film (film scanner, analysis software)
- MOFETs (optional)
- MapCHECK (optional)
MapCHECK™

Solid state circuitry in an acrylic housing, with the 445 diode detectors

Extended Dose Range film (EDR2)

<table>
<thead>
<tr>
<th>Strip Number</th>
<th>MU</th>
<th>Dose (Gy)</th>
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<tbody>
<tr>
<td>1</td>
<td>1x3</td>
<td>10.8</td>
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<tr>
<td>2</td>
<td>5x3</td>
<td>21.9</td>
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<td>3</td>
<td>10x3</td>
<td>36.9</td>
</tr>
<tr>
<td>4</td>
<td>20x3</td>
<td>63.8</td>
</tr>
<tr>
<td>5</td>
<td>30x3</td>
<td>91.3</td>
</tr>
<tr>
<td>6</td>
<td>50x3</td>
<td>150.0</td>
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<tr>
<td>7</td>
<td>70x3</td>
<td>208.6</td>
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<tr>
<td>8</td>
<td>90x3</td>
<td>264.0</td>
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</table>

100 SSD, 3 cm depth

Multiple Point Dose Verification

Ion chamber
MOSFETs – Similar to diode detector

Calc. 2.18 Gy
Meas. 2.09 Gy
Diff. 4.35%

Calc. 1.37 Gy
Meas. 1.42 Gy
Diff. 3.52%

Calc. 0.81 Gy
Meas. 0.78 Gy
Diff. 3.45%

Calc. 0.82 Gy
Meas. 0.86 Gy
Diff. 4.63%

MLC Plan Isodose Verification

0.40 Gy, 0.30 Gy, 0.20 Gy, 0.10 Gy
**Point Dose Verification**

![IMRT Measurement Results](image)

**Deviation between measured dose and planned dose at low dose regions**

![Graph showing deviation](image)

**Dose Verification Acceptance Criteria**

- For high dose regions (>80%), less than 5% discrepancy between the measured and calculated doses
- For low dose regions (30~ 50%), less than 5% discrepancy between the measured and calculated doses when both normalize to the maximum dose.

**Table Attenuation**

- IMRT requires more beam angles than conventional treatment to achieve high conformity in dose distributions.
- Carbon fiber tabletop can reduce beam attenuation but the attenuation may vary depending on the thickness of materials.

**Conforming Tabletop**

![Conforming Tabletop](image)
**Special Clinical Problems: Skin Dose Problem**

- Multiple tangential beams decrease skin sparing
- Bolus effect, due to the use of the head-shoulder mask, increases skin dose about 15% when compared with and w/o the head-shoulder mask
- In order to cover superficial nodes, the inverse planning system increases beam intensity on the neck skin
- Contour neck skin as a sensitive structure to avoid the high dose on the neck skin

**Patient Skin Dose Problem**

Patient with marked skin reaction
**Skin Dose Investigation**

<table>
<thead>
<tr>
<th></th>
<th>Opp. Lateral</th>
<th>IMRT w/ skin included</th>
<th>IMRT w/ skin excluded</th>
<th>IMRT w/skin excluded + skin spare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. Daily dose (Gy)</td>
<td>1.53 ± 0.39</td>
<td>1.31 ± 0.31</td>
<td>1.82 ± 0.13</td>
<td>1.66 ± 0.15</td>
</tr>
<tr>
<td>Ave. Total dose (Gy)</td>
<td>50.83</td>
<td>43.12</td>
<td>60.10</td>
<td>54.64</td>
</tr>
</tbody>
</table>

**Summary of Patient Specific QA**

- Patient setup and immobilization
- Treatment plan QA
- Treatment Verification (Iso-center, intensity map check, and delivered MU)
- Dose Verification
- Special clinical problems