CLINICAL IMPLEMENTATION OF RAPIDARC

Treatment Planning Strategies to Improve Dose Distributions

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Overview

- Commissioning experience.
  - Eclipse TPS
  - dMLC QA
  - Patient specific QA

- Presentation will focus on our RapidArc treatment planning strategy.
  - Initially underestimated this task....
Varian Demo Plan

**IMRT Treatment plan**
- 1147 MU and 5.5 min
- 3D dose max = 108.8 %

**RapidArc Plan**
- 804 MU and 1.5 min
- 3D dose max = 114.7 %

Can we achieve dose distributions similar to our institution's prostate IMRT?
### IMRT Treatment Plan

**DVH Criteria for 76 Gy in 38 Fx**

<table>
<thead>
<tr>
<th>CTV</th>
<th>V100</th>
<th>≥</th>
<th>76</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV</td>
<td>V98%</td>
<td>≥</td>
<td>76</td>
</tr>
<tr>
<td>Rectum</td>
<td>V60%</td>
<td>≤</td>
<td>40</td>
</tr>
<tr>
<td>Rectum</td>
<td>V50%</td>
<td>≤</td>
<td>45</td>
</tr>
<tr>
<td>Rectum</td>
<td>V40%</td>
<td>≤</td>
<td>60</td>
</tr>
<tr>
<td>Rectum</td>
<td>V20%</td>
<td>≤</td>
<td>70</td>
</tr>
<tr>
<td>Rectum</td>
<td>V15%</td>
<td>≤</td>
<td>76</td>
</tr>
<tr>
<td>Rectum</td>
<td>V5%</td>
<td>≤</td>
<td>78-80</td>
</tr>
<tr>
<td>Bladder</td>
<td>V20%</td>
<td>≤</td>
<td>70</td>
</tr>
<tr>
<td>Femoral Heads</td>
<td>V50%</td>
<td>≤</td>
<td>45</td>
</tr>
<tr>
<td>Femoral Heads</td>
<td>V10%</td>
<td>≤</td>
<td>50</td>
</tr>
</tbody>
</table>
IMRT Treatment Plan
8 Beam Technique
In addition to DVH constraints, plan should minimize high isodose lines that bisect the rectum.

The 30 Gy line should be conformal and not cover the posterior wall of the rectum and at minimum at least 45 Gy should always split the rectum.
Developing a “Comparable” RA Treatment

1st Attempt

- First Attempt – 360° arc (collimator 45°), typical constraints for bladder, rectum, and femoral heads.
Developing a “Comparable” RA Treatment
1st Attempt Results
Developing a “Comparable” RA Treatment

- 2\textsuperscript{nd} Strategy: 360° arc (collimator 45°), typical constraints for bladder, rectum, and femoral heads + NT objectives & avoidance structures.

- 3\textsuperscript{rd} Strategy: 300° arc (collimator 45°), typical constraints for bladder, rectum, and femoral heads + NT objectives and avoidance structures.
Developing a “Comparable” RA Treatment Strategy that Achieved the “Best Results”

- Two 300° arcs typical constraints for bladder, rectum, and femoral heads + NT objectives, avoidance structures, and a planning PTV.

Arc Angles:
210° – 150° CW, C=30°
150° - 210° CCW, C=330°

Note: Offset collimator rotation ± 30° offsets interleaf leakage.
Avoidance Structures 1 and 2

Avoidance Rings: very similar to rings used by GU service for IMRT treatment planning.

Ring 1: 1 cm expansion of PTV (remove PTV + 1 mm).
Ring 2: 2 cm expansion of PTV, (remove PTV +1 mm and ring 1).
Avoidance Structures 3 and 4

Avoidance Structures:
- Overlap of rectum and ring 1.
- Overlap of rectum and ring 2.
Avoidance Structures 5 and 6

Expansions of Ring1 + Rectum:

Posterior Avoidance 1 (small)
- 1.5 cm laterally
- 5 cm posteriorly

Posterior Avoidance 2 (large)
- 4.5 cm laterally
- 5 cm posteriorly
Planning PTVs

- In general, RA plans tend to be “hot” on the superior and inferior slices.
- Create Planning PTVs to cool down superior/inferior slices and maintain dose to rest of PTV.

**Treatment Planning PTVs**
- Planning PTV1 = Only the sup/inf slices of PTV
- Planning PTV2 = PTV – Planning PTV1

**Dose Criteria for Planning PTVs**
- 5% less dose to planning PTV 1

**Evaluation Criteria for Treatment Plan**
- Evaluate DVH for “original” PTV

Acknowledgement: This technique was recommended by Charles Mayo, PhD, Umass Medical Center
Best Results

Recall our first attempt plan:

And now our “best” result plan:
Best Results

Fall-off distance between 70Gy and 40Gy isodose lines is 0.5cm.
Why was 2 arcs better than 1?

Twice as many control points allow more dose modulation.
Monitor units for RapidArc plans are (usually) lower than for sliding window IMRT.

- Can be as much as 40 to 50% lower.
- MU increase with plan complexity and the number of times that optimization is repeated.
END

Questions?
Andrew Lee, M.D., Reviewed numerous treatment plans and helped develop the planning strategy.

Physics Assistants:
- Scott LaNeave, Jared Ohrt, and Luke Whittlesey, provided assistance with demonstration and training regarding the current IMRT QA protocol and OmniPro software.
- Jennifer Johnson, assisted with the Diamond calculation test.
- Charles Mayo, PhD
If there is extra time permitting...

RapidArc Commissioning and QA Experience at M.D. Anderson.
RapidArc QA Overview

- **Eclipse Commissioning**
  - Configured photon beam models
  - Validation of Photon Models

- **Routine Monthly QA Specific to RapidArc**
  - Dynamic MLC QA (necessary for “sliding window” IMRT)
  - Constancy verification of RapidArc plan using monthly QA Setup

- **Patient specific QA**
  - Dynalog files
  - Film and ion chamber measurements
Monthly QA

Constancy Verification of RapidArc Delivery

1. Created verification plan of prostate plan using CT data set of the monthly QA phantom.
2. Determined dose to ion chamber (from Eclipse DVH).
3. Delivered RA plan to phantom, measure dose, and compare measured and calculated doses.

This procedure is included in routine monthly linac QA.
As part of commissioning, we delivered treatment 3X, and reviewed dynalog files.

- Maximum leaf position deviation for all 3 runs was in the range of 1mm to < 1.5 mm.
  - The maximum deviation occurred for less than 3% of the leaf positions for all 3 deliveries.
  - Negligible dosimetric effect.

- Recommend dynalog file analysis 3X during a patient’s course of treatment.
Patient Specific QA

Film and Ion Chamber QA analogously to our IMRT QA procedure:
- Create verification plan in Eclipse for OmniPro phantom.
- Deliver dose to phantom.
- Compare measured and calculated ion chamber dose and film dose.
Patient Specific QA
Ion Chamber/Film Results

- Absolute dose agreed within 1%.
- > 90% of film pixels had gamma ≤ 1.0 (3% and 3mm).
- Results have all been >95% passing.

<table>
<thead>
<tr>
<th>Field</th>
<th>Energy (MV)</th>
<th>Couch</th>
<th>Coll</th>
<th>Gantry</th>
<th>MU</th>
<th>Ion Chamber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Readings (nC)</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>0</td>
<td>45</td>
<td>179.9-180</td>
<td>792</td>
<td>3.796</td>
</tr>
</tbody>
</table>

Total Measured = 330.8
Calculated Dose = 328.0
% diff = 0.9%

The ratio of the measured to calculated dose is between 0.95 and 1.05, monitor units do not need adjustment.

**Absolute Dosimetry Results - Ion Chamber Data**

**Relative Dosimetry Results - Film Data**

a. Eclipse Dose Plane
b. Measured Film Dose
c. Film Gamma
d. Isodose Overlay
Treatment Interlocks

- If an interlock is asserted during treatment, follow normal procedures to clear interlock.
  - If able to clear interlock, treatment will resume from point where interlock asserted.

- Interlock will not affect the accuracy of dose delivered to the patient.
  - Tested by inserting interlock during treatment of QA phantom and then resuming treatment.
  - Film and ion chamber data were analyzed.
    - Absolute measured dose agreed with plan dose within 1%.
    - The film analysis: >99% of the pixels had a gamma ≤ 1
Partial Treatments

- If interlock can not be cleared and have true partial treatment, the partially treated plan can be reconstructed in Eclipse to assess the dosimetric impact.

- QA was performed on the “partially” delivered plan.
  - Results were comparable to full treatment delivery.

To assess the dose delivered from a partial delivery - Adjust this value to the MU delivered.

In this example, the treatment was stopped after delivery of 400 MU. Gantry end angle is 0.0. The Gantry end angle can be was compared to stop angle during treatment delivery.

Eclipse calculation for one fraction partial arc 0 to 400 MU.
Partial Treatments

- It is also possible to calculate partial plan that begins where the interrupted arc ended.
- Then, the second portion of the plan can be delivered.
- QA was performed on the “partially” delivered plan.
  - Results were comparable to full treatment delivery.