Integrating the MR-Linac into Radiation Therapy Practice

Mikki Campbell MRT(T), MHE
Winnie Li MRT(T), MSc

UTDRO Evening Journal Club
MR-Linac: From Prototype to Clinical
January 24, 2019
Objectives

• To review the benefits, challenges and clinical implications of the MR-Linac on radiation therapy practice

• To discuss what scope of practice changes will emerge from the implementation of the MR-Linac and the impact it will have on education and regulation
**MRGRT - SWOT**

**Strength**
- Improved image quality
- Beam-on images
- On-board functional imaging
- Avoid exposure to imaging dose

**Weaknesses**
- Health economics
- Fraction times
- Deformable registration accuracy
- Magnetic field
- Bore size
- Geometric deformation & MRL calibration

**Opportunities**
- Newly developed workflows
- Ultrahypofractionation
- Research

**Threats**
- Workflow & software development
- Intrafraction motion
- Suboptimal patient selection
- Staffing
- Evidence of clinical benefit
## MR-Linac Workflow

<table>
<thead>
<tr>
<th>Imaging</th>
<th>Pre-Beam</th>
<th>Beam-On</th>
<th>Post-Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI (3D, 4D)</td>
<td></td>
<td>Real-Time MRI (Cine, 3D)</td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>Adapt Re-plan</td>
<td></td>
<td>Accumulate Dose</td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td>Radiation Delivery (gating, tracking)</td>
<td></td>
</tr>
</tbody>
</table>

Courtesy Dr. Allen Li, MCW
Clinical & Technical Considerations

Simulation/Planning

- MRI planning (sequence optimization)
  - MRI eligibility (initial)
- Patient positioning/immobilization devices
- Motion management
- CT planning
  - Back-up plan for CBCT Linac
- Monaco templates for reference planning
Patient Positioning & Immobilization

- Position of the patient and size of accessories are limited by the size of the bore (arms up vs. arms down)
- All accessories must be MRI compatible and indexed
- Coil indexed
Monaco Planning Considerations

• 57 cm (W) x 22 cm (L) max field size (fixed collimator)

• Avoid gantry angles through couch/coil mechanics

• Avoid gantry angles through cryostat

• IMRT/ 3D Conformal Only (no VMAT)
Monaco Templates

Templates store beam geometries, calculation parameters, calculation settings, physician’s intent, IMRT constraints, etc.

- Plans = more heterogeneous

<table>
<thead>
<tr>
<th>Structure</th>
<th>Cost Function</th>
<th>Enabled</th>
<th>Status</th>
<th>Manual</th>
<th>Weight</th>
<th>Reference Dose (cGy)</th>
<th>Multicriteria</th>
<th>Isosurface</th>
<th>Isoeffect</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LENS_Rorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LENS_Lorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRAINSTEM_Rorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTICOCAPS_Rorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTICOCAPS_Lorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTICERVE_Rorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTICERVE_Lorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye_Rorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye_Lorig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- RT Sided

- Midline

- LT Sided
Clinical & Technical Considerations

Treatment Delivery
- Anatomic sites
- Pre-beam, Beam-on & post-treatment imaging
- Daily MR eligibility
- ATP vs. ATS
- No laser system
- No MLC tracking, automatic gating, multi-structure motion monitoring, dose accumulation

• Other Considerations:
  - Patient/staff scheduling
  - Partial treatment workflow
  - Patient communication
## Imaging Workflow

<table>
<thead>
<tr>
<th>Pre-Treatment</th>
<th>Motion Monitoring</th>
<th>Verification</th>
<th>Intra-fractional</th>
<th>Post-Delivery</th>
</tr>
</thead>
</table>
| • 3D image acquired from treatment console  
• Pre-sets provided  
• Drives adaptive plan | • Optional 2D cine  
• Can select anatomical plane | • Re-acquisition of pre-treatment preset before adapted plan approved  
• Register image of the day with verification as a visual check to ensure patient hasn't changed significantly | • Optional 3D intrafractional intended for beam-on imaging  
• Only able to have one beam-on imaging activity (i.e. motion monitoring OR intrafraction imaging)* | • Customized pre-sets available  
• Potential to use in offline Monaco  
• Novel research sequences |
Protocols for Adaptation

Anatomical
- Ex. Contour change, bladder filling, rectum filling, seminal vesicles outside PTV

Dosimetric
- Adaptive plan better than reference?
- Adaptive plan is different, but within limits?
- Adaptive plan is worse, not within limits?

Physics
- MU check
- Segment check
- Largest aperture
Training Considerations

• New treatment planning system
• MR safety, patient screening
• MR-based anatomy
  – Image assessment on MRI vs CBCT vs CT
• MR image quality, scan optimization & interpretation
• Daily/weekly QA requirements
Team Development - Sunnybrook

Clinical Specialist Radiation Therapist (CSRT)

**Monaco Super User** (experienced therapist with minimal Pinnacle experience)
- Responsible for preparing the Monaco treatment planning platform for clinical use

**Imaging Super User** (RTT/RTMRI)
- Responsible for preparing the imaging platform for clinical use

**MR-Linac Rotational Positions** (x4)
- Responsible for all aspects of planning and treatment for patients scheduled to the MR-Linac
- Two of the staff selected were certified RTT/RTMRI
Team Development - PM

• Super Users with combination expertise:
  – Monaco
  – MR imaging
  – Clinical implementation
  – Treatment planning
  – Image guidance (online and adaptive)
MRL Workflow Models

• MRL workflows will be very different
  – 3-4 RTs staffed on MRL (± RO, MP)
    – RT(T) vs RT(MR) vs RT(T, MR)
• Pt in and out of room in 26 min is possible
  – ~45-60 min typical/reported for actual patients
• Some sites looking into MD-independent workflows
  – MD vs RT vs computer for contours / plans / approval
Final Thoughts

1. How will the integration of MRI further expand radiation therapy practice?

2. With integrated MR-Linac systems and adaptive RT, what does this mean for our workflows and our patients?

3. What scope of practice changes will emerge?

4. What impact will integration have on entry level certification, on accreditation, on regulation?