Applicator Commissioning and Workflow Development for the Implementation of MRI in High Dose Rate Brachytherapy

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Disclosures

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Objectives

• To understand the benefits of having an MR-based HDR GYN BT program

• To understand practical considerations that arise for workflow development and applicator commissioning
  – TG-303 “MRI Implementation in HDR brachytherapy - considerations from simulation to treatment”
  – GYN and prostate
  – Today I’ll focus on intracavitary GYN, but concepts apply to prostate and interstitial
Benefits of an MR-based Program

- Visualize tumor geometry (in addition to applicator geometry)
- Assess dose to tumor and OARs from EB + BT (collect D-V metrics in spreadsheets)
- Adapt dose during treatment → image-guided adaptive BT (IGABT)
- IGABT combined with chemo leads to excellent LC (91%), PC (87%), OS (74%), CSS (79%) throughout all stages, with limited severe morbidity @ 3 yrs (RetroEMBRACE)

Sturdza et al, Radiotherapy & Oncology, 2016
Where to Start?

Transition to 3D BT via CT

- Learn aspects of 3D planning process using a more familiar / available imaging modality
- Set a baseline, a reference for MR-based commissioning

Implement MRI-based planning
Transition to MR-based BT

Better prepared to commission MRI-based planning:

• Decide on the workflow, scope of MRI (new)
• Expand your team to include MR expertise (new)
• Commission the MR simulation & image acquisition process (very new!)
• Implement MR safety measures (very new!)
• Commission the MR planning process: Image import, planning, & dosimetry processes (similar)
  • Contouring (improved, ↑ in information)
  • Applicator definition (similar, ↓ information and distortions/artifacts, can use CT as your reference!)
• Isodose planning (same)
• DVH evaluation (same)
• Dose tracking over multiple fractions, summation with EBRT (same)
• Dose adaptation (improved!)
Decide on the Workflow

- Different workflows:
  1. “MR-informed”
  2. “MR-guided”
  3. “MR-based” (most common)
- Could be one or a combo of the above
- Let’s focus on MR-based BT approaches

*J. Wang et al. / Brachytherapy 16 (2017) 715–727*
MR-based BT: MR-only Approach

MRI acquired for each fraction is the ideal MR-based approach

- Resource-intense to acquire MRI for every fraction
- Need adequate access to a dedicated MR scanner
- Highly recommended to acquire CT and MR in parallel for first few cases (learning curve)
MR-based BT: CT/MR Hybrid Approach

Hybrid approach often utilized when MRI access is limited (one example):

- MRI acquired early during BT process (e.g., first fraction)
- CT acquired for subsequent fractions & registered to first fraction MRI
- MRI for target delineation, CT for applicator reconstruction and to define the critical structures (primary dataset)
- Registration may be challenging -- Potential variations in position of applicator and anatomy
Expand (and Prepare) Your Team

- We are used to working with multi-disciplinary teams in Brachy
- Expand your team to include MR expertise—MR radiologist (initially), MRI physicist, and MRI technologists
Commission MR BT Sim and Image Acquisition Process
MRI Unit

- Internal or External to Dept
- Diagnostic MR scanner → RO MR simulator
- Dedicated RO-specific MR simulator
- Large bore size:
  - ~70 cm bore (~44 cm)
- “MR-RT” options
  - Flat tabletop
  - External laser positioning system
  - MAR software
  - Respiratory triggering
- Strength (1.5-T or 3-T*)
  - Susceptibility artifacts, heating
Patient Preparation Procedures

- Screening: initially at consult, verified prior to MR-sim for every fraction
- Clothing: Hospital-provided gowns. No metal (e.g., underwire from bra). Shoes are removed.
- Positioning: Supine, level, legs as straight as possible, feet banded, towels between implant and skin, holding ring on chest, ear protection
- MR-safe transfer equipment
Develop MR Imaging Sequences

• Work with an MRI physicist
Commission Applicators for MRI

- Construct a QA phantom, fix applicator in tissue-equivalent material (e.g., Agarose gel)
- Image phantom on CT for reference, and on MRI for sequence development
- Register, evaluate applicator visualization & reconstruction accuracy in phantom
- Continue evaluation in clinical scans, may require further adjustment of parameters
- What’s ideal for applicator, may not be for tissues/target – may need multiple sequences (to get the “whole story”)

Commission Applicators for MRI

- Great way to learn about distortions and artifacts, especially for Ti applicators
- The level of distortions and general image artifacts (e.g., truncation, aliasing, magnetic susceptibility, chemical shift artifacts) should be validated for specific conditions:
  - Applicator material, tesla strength (higher SNR at cost of increased artifacts), specific array coils, imaging sequence
- Minimize geometric errors to minimize dosimetric uncertainties (<3mm, <10%) (Schindel et al. JCB 2013;5:250-257., and Tanderup et al.)

**MR Safety Testing during Applicator Commissioning**

- In addition to commissioning for visualization/reconstruction accuracy, commissioning also includes **safety testing**.

Some key safety tests (TG-303):
- Review the applicator-specific “Instructions for Use” (IFU).
- Prior to any scanning: verify device labeled MRI-conditional and know what those conditions are (field strength).
- RF not ionizing but can cause heating – Specific Absorption Rate [SAR] is a measure of energy deposition (watts/kg), know the SAR limits.
- Verify SAR is not exceeded for the different sequences (Multiple sequences → cumulative SAR).
MR Safety incorporated into Workflow

- Implement a screening process prior to appointment → includes “research” of existing implanted objects (manufacturer-provided specs, or internet search: mrisafety.com)
- Ensure MR safety of applicator, patient transfer systems, patient clothing
- Ensure MR safety of patient positioning w/in bore to avoid thermal injuries, checking contact with coils, avoiding projectiles, hearing protection
- Consider use of plastic needles over Ti needles (heating, artifacts)
- Published general MR safety recommendations — ACR Guidance Document on MRI Safe Practices
- MR safety training (initial and refresher)
Summary

• Benefits of having an MR-based HDR GYN BT program
  • Improved clinical outcomes
• Practical considerations for workflow development and applicator commissioning
  • Define scope of MRI in your workflow (logistical considerations)
  • Integrate MR experts into your team (MR physics & MR technologist)
  • Start with CT → transition to MRI → learning & process improvement continues
  • Commissioning includes MR safety as well as MR image quality
Thank you!

AAPM, TG-303, and my brachy team!