Starting an MRgRT Program: installation, safety considerations, and commissioning

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Disclosure

• Honoraria and travel grants from ViewRay, Inc.

Outline

• Current status of MRgRT systems
• Site Planning
• Staff Training and Patient Safety
• Commissioning
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Current status of MRgRT systems

• Basic characteristics of commercially-available systems

Elekta Unity

- 7FFF linac
- EPID
- 55x22 cm² field size
- 160-leaf MLC
- 1.5 Tesla

ViewRay MRIdian

- Three Co-60 sources
- 555 cGy/min
- Single-stack MLCs
- 105 SAD
- Split doughnut 3.5:7 MRI
- 4-lbs sagittal plane imaging
- Real-time gating

- 6FFF linac
- 600 MU/min
- Doubly-stacked MLC
- 90 SAD
- 24x27 cm² field size
Current status of MRgRT systems

- Proliferation of 0.35-T MRLinac units:

https://viewray.com/clinical-affairs/

Both 0.35T & 1.5T: 21 clinical units worldwide

Compare with 27 proton centers in USA, 73 worldwide

https://www.elekta.com/radiotherapy/treatment-delivery-systems/unity/mrt/

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Site Planning – Access Control Requirements

• ACR guidance on MRI Zone Delineation
  - Zone I: general public
  - Zone II: unscreened patients under supervision of MRI personnel
  - Zone III: screened patients under supervision of MR personnel only, restricted from general public access, visitors must also be screened
  - Zone IV: MR scanning room itself

Site Planning – Quench Pipe & Other Ducts

- Both commercially-available systems utilize superconducting magnets filled with helium at 4K
  - The gases must have an escape path in case of instability
  - The quench pipe often cannot have the necessary bends to reduce shielding requirements (as with HVAC) due to maximum pressure limitations to ensure gases escape quickly and harmlessly
- Especially tricky for radiotherapy departments due to their commonly underground locations
- There will be other vault penetrations for cables coming from auxiliary equipment rooms
  - Majority of electronics and cooling equipment located outside the vault
  - These penetrations must be both RF and radiation-shielded

Site Planning – Fringe Magnetic Fields

- Manufacturer should provide map of fringe fields
- Must identify and mark the 5-Gauss line
  - The region beyond which magnetic fields can become harmful
- Must consider equipment adjacent to MRgRT vault
Site Planning – Fringe Magnetic Fields

- Example of fringe field interference: ViewRay & Tomotherapy
  - Steel plate installed in the wall between the two vaults, taking the fringe field down to the level of the Earth (0.5 Gauss)

- Example of fringe field interference: Elekta and Elekta
  - A weak field at the standard linear accelerator resulted in a significant change to flatness and output that was not able to be fully corrected by the linac’s servos.
  - After the 1.5-T magnet was stabilized, the adjacent linacs were recalibrated


SAM Question

The 5-Gauss line is:

A. A pixel line in the matrix
B. The magnetic field line territory within which the magnetic field can become harmful
C. A catheter inserted into the femoral artery
D. A geometric theorem
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Staff Training and Patient Safety

• Staff training – adhere to ACR guidelines
  - MRI director
    - Physician responsible for establishment and adherence to MRI safety guidelines by all staff
  - Level I training – general MRI safety, does not grant unescorted access
    - Should be required of all clinical and engineering staff in radiotherapy as well as all cleaning staff
  - Level II training – unescorted access
    - Should be required of all physicians, physicists, residents, nurses, therapists
    - Anyone who may screen patients and visitors
Staff Training and Patient Safety

- **Patient Safety**
  - The patient must be screened more than once for MRgRT specifically:
    1. At time of initial consultation
    2. At time of simulation (even if not using MRI or MRgRT for sim)
    3. At time of first fraction
    4. At time of every subsequent fraction (at least an abbreviated version)

*Never assume that just because a patient had a prior MRI scan that they are safe!*

Staff Training and Patient Safety

- **Patient Safety – emergency procedures**
  - Emergency response personnel must be aware of MRI field
  - An MR-compatible stretcher may be used to transfer patient from MRgRT vault to maze or just outside, where the emergency response team may treat them without fear of ferromagnetic equipment entering the main vault


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Commissioning - Simulation

- Immobilization and positioning device selection
  - Check with manufacturer regarding MRI compatibility of existing products
    - E.g., Vacloc bags, Alpha cradles already MR-compatible
  - Solutions starting to appear for head and neck immobilization
    - Cannot use the standard HN board as it is typically carbon fiber
  - Must evaluate the effect on image quality if immobilization/positioning device increases distance between patient and receiver coils

Commissioning - Simulation

- Patient hearing protection
  - May be too large to be comfortably worn in the arms-up position
  - May be impossible to combine with head immobilization

Commissioning - Simulation

- Patient hearing protection
  - Ear plugs are a potential solution
  - Must educate patient to alert staff if they fall out
Commissioning – Considerations for Daily Treatments

- Patient preparation for radiotherapy, especially adaptive
  - Maximize efficiency by minimizing amount of variation in internal anatomy
    - NPO for 2 hours prior to treatment
    - Avoid iron fortified foods and vitamins for duration of treatment

- Patient monitoring devices (interaction with image quality)
  - It is possible to use anaesthesia and patient monitoring, but care must be taken to evaluate impact on image quality
    - There are no windows in MRgRT vaults! Must have additional cameras
  - Devices are typically tested in diagnostic MRI scanners, there may be RF noise interfering with MRgRT systems specifically
  - Consult with radiology department for more complicated cases

Summary

- The proliferation of MRgRT units allows for sharing of experience with installation and implementation
  - Task groups and working groups are actively being organized and guidance is forthcoming
- There is established guidance regarding MRI safety from ACR, but care must be taken as MRgRT patients will be receiving multiple scans and encountering multiple personnel
- It is beneficial to align with a neighboring radiology department but do not assume their procedures are sufficient