MR in radiotherapy planning

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Presentation outline

• MR/CT based workflow
  What is the problem?
• MR only workflow
  Issues and possibilities
• Treatment planning systems
  What is needed before we can make full benefit of MR?
• Image quality and distortions

Why?

Van der Heide et al.
Future Medici (2011)
Registration / Target definition

**Workflow of today**

- Images
- Registration / Target definition
- Treatment planning

**Problem**

**Registration**

- **Method**: MR and CT examinations of head case were sent to 45 clinics for registration
- **Result**: Standard deviation: 2.2 mm

**Switch from CT based to MR based workflow**

- Imaging
- Target definition
- Treatment planning
Which issues needs to be addressed

- Geometrical accuracy
- Imaging of markers

McJury et al. BJR 2011
Which issues need to be addressed:

- Geometrical accuracy
- Imaging of markers
- Imaging in fixation
- Dose calculation
- Positioning reference

Not specific for MR only radiotherapy

Specific for MR only radiotherapy
How?

Dose calculation  Positioning reference

MR  CT equivalent

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MR signal

T2w  CT  UTE (Ultra short echo time)

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Manual segmentation and bulk densities

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Manual segmentation and bulk densities

Advantage
• High dosimetric accuracy
• Intuitive method

Disadvantage
• Very time demanding
• Geometrical accuracy?

Registration based

An Atlas-Based Electron Density Mapping Method for Magnetic Resonance Imaging (MRI)-Azone Treatment Planning and Adaptive MRI-Based Prostate Radiation Therapy

Difference in calculated dose

Manual segmentation and bulk densities

Advantage
• High dosimetric accuracy
• Intuitive method

Disadvantage
• Very time demanding
• Geometrical accuracy?

Registration based

MRE-Based Attenuation Correction for PET/MRI: A Novel Approach Combining Pattern Recognition and Atlas Registration

Advantage
• High dosimetric accuracy
• Automatic

Disadvantage
• Geometrical accuracy?
Automatic segmentation and bulk densities

Investigation of a method for generating synthetic CT models from MRI scans of the head and neck for radiation therapy

MRI-Based Attenuation Correction for Hybrid PET/MRI Systems: A 4-Class Tissue Segmentation Technique Using a Combined Ultrashort-Echo-Time/T1200 MRI Sequence

Automatic, three-segment, MRI-based attenuation correction for whole-body PET/MRI data

Air
Air/soft tissue
Soft tissue
Bone
Bone/soft tissue
Automatic segmentation and bulk densities

**Advantage**
- High dosimetric accuracy
- High geometrical accuracy

**Disadvantage**
- Not intuitive – Need for QC
- Not shown to work below the H&N region

Direct voxel-vise conversion

CT substitute derived from MRI sequences with ultrashort echo time

MRI-based treatment plan simulation and adaptation for ion radiotherapy using a classification-based approach

Treatment planning of intracranial targets on MRI derived substitute CT data

Gamma maps 3%-3mm

Geometrical accuracy

Treatment planning of intracranial targets on MRI derived substitute CT data
Jonsson et al. – Radiotherapy and oncology
Comparison CT/substitute-CT

**Advantage**
- High dosimetric accuracy
- High geometrical accuracy

**Disadvantage**
- Not intuitive – Need for QC
- Not shown to work below H&N region

TPS and MRI

Target delineation

- Today:

Dose calculations

- Tomorrow:

Image quality

(some personal reflections)

The definition of the target volume and OAR's are the most important steps of the radiotherapy workflow.

Point with MRI: Image quality ⇒ better possibilities to define relevant volumes

So we should do what we can to maintain the image quality.

This could mean that RT needs to adopt to MR instead of the other way around.
Image quality
(some personal reflections)

Patient dependent
Gradient none-linearity

Distortions
Target definition
Dose calculation (MR only workflow)
Registrations (CT/MR workflow)

“Patient related image distortions can be reduced by applying relatively strong slice selection and frequency-encoding gradients, for example, by setting the pixel bandwidth at twice the water-fat shift, all patient related distortions are expected to be smaller than the pixel size.”

440 Hz at 1.5 T
880 Hz at 3 T
Distortions

Patient dependent
Gradient none-linearity

1.5T

3T

Thank You!

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