

# MRI Guidance in the Radiation Therapy Clinic: Site-Specific Discussions

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In this presentation, the commonly employed MRI sequences in radiation oncology practice will be discussed. Specifically, the presentation will include the following parts:

**Part-1.** Brief review of commonly used MR sequences used in radiation oncology

- T1 weighed: higher signals with fat, less for fluid
  - gadolinium enhanced images: scans are obtained a few minutes after administration to show inflammatory changes or invasive changes of tumor.
  - fat suppressed images to darken the fat to show more contrast
- T2 weighed: high signals with fluid and fat. It is often used to show pathology, such as solid tumors.
  - fat suppressed (STIR): to show edema
  - fluid attenuated (FLAIR): to suppress CSF and show edema
  - susceptibility sensitive (T2\*, SWI):
- Proton density weighed: high signals with fluid, fat; low in cartilage
- Diffusion weighted: assess the ease with which water molecules move around within a tissue (intracellular and extracellular spaces) and cellularity (e.g. tumors), cell swelling (e.g. ischemia) and edema.
  - DTI, diffusion-tensor imaging, has served as the basis for brain white matter tractography, but more advanced techniques are currently used to take into account voxels with multiple fiber orientations.
- MR spectroscopy
- MR perfusion: assess the amount of blood flowing into tissue ischemic stroke, histological grade of certain tumors, or distinguishing radionecrosis from tumor progression.

**Part-2.** Limitations of non-dedicated MR used for guiding RT planning and suggestions

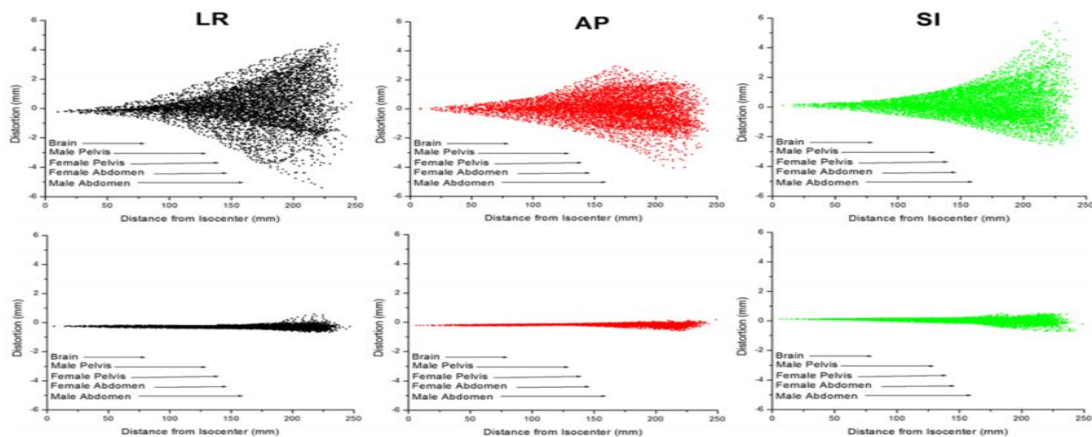
Classifications of the artifacts include:

- MR hardware and room shielding
  - zipper artifact: where one or more spurious bands of electronic noise extend perpendicular to the frequency encode direction and is present in all images of a series. Remedy: make sure the MR scanner room-door is shut during imaging; remove all electronic devices from the patient prior to imaging
- MR software
  - slice-overlap artifact (also known as cross-talk artifact): bladder
- Patient and physiologic motion
  - phase-encoded motion artifact: manifests as ghosting in the direction of phase encoding, usually in the direction of short axis of the image (i.e left to right on axial or coronal brains-*sigmoid sinus*, and anterior to posterior on axial abdomen).
- Tissue heterogeneity and foreign bodies
  - susceptibility artifact/magnetic susceptibility artifact: metal
  - chemical shift artifact: It occurs in the frequency encode direction where a shift in the detected anatomy occurs because fat resonates at a slightly lower frequency than water. Remedy: use fat suppressed imaging, or use a spin echo sequence instead of a gradient.
  - Motion artifact

When encountering an unfamiliar artifact, it is useful to systematically examine general features of the artifact to try and understand its general class and find its remedy.

### Part-3. Site Specific Discussions

- Brain
  - When perform MR, head coil shall be placed to achieve the uniform MR field. If the metal immobilization pins are used during MR scan, 3.0-T MR scanner demonstrated greater geometric shifts than that from 1.5-T MR.
- Head and Neck region
  - Distortion increases as a function of distance from magnet isocenter for one scan, mainly due to gradient nonlinearity. Corrections can be effectively made using postprocessing correction functions.



- **Prostate**

Its “capsule” in MRI is an important landmark for assessment of extra-prostatic tumor extension, since irregularities, bulges, and disruptions of the capsule are signs of tumor invasion or spread outside the confines of the prostate. 95% of prostate cancers are adenocarcinomas that arise in the glandular tissue, with about 70% originating in the peripheral zone, 25% in the transition zone, and 5% in the central zone. A series of studies in the late 1980s established that prostate cancer is characterized by low T2 signal intensity replacing the normally high T2 signal intensity in the peripheral zone. However, its specificity is weakened by other possible causes, including hemorrhage, prostatitis, scarring, atrophy, and effects of radiation therapy, or hormonal therapy.

Diffusion-weighted imaging (DWI) provides an important quantitative biophysical parameter that can be used to differentiate benign from malignant prostate tissue. However, acquisition-specific distortions as well as physiological motion lead to misalignments between T2 and DWI ( $2.21 \pm 1.00$  mm, ranging 1.12 to 4.77 mm, n=20) and consequently to a reduced diagnostic value.

MR spectroscopy (MRS) uses (choline + creatine)/citrate ratio to detect malignancy with its low value. Despite its relatively high specificity (and low sensitivity), false-positive MR spectroscopic interpretations can result from the seminal vesicles, stromal BPH, prostatitis, and focal prostatic atrophy.

- **Liver**

DWI is more sensitive for the detection and characterization of liver metastases from neuroendocrine tumors than T2-weighted fast spin-echo images. Dynamic gadolinium-enhanced MR imaging and should be systematically performed.

In order to maintain a uniform image along all directions, the coil needs to be positioned not only with minimal BTC distance but also parallel to the phantom surface. By systematically increasing the BTC distance, we found that among all organs of interest, the bladder is the most sensitive to the anterior BTC distance change.

- **Pancreas**

Fiducial markers are often used and may affect quality of MRI. They will generate susceptibility artifact/magnetic susceptibility artifact.

Many preclinical and clinical studies in various body parts have been conducted to assess tumor response by using DW MR imaging. Currently, no study has reported DW MR imaging to be useful in assessing pancreatic tumor response.

- **Spine**

In MR scan, magnetic field gradients (solid line) often encode position to frequency. Its gradient linearity is high near isocenter but falls off with increasing distance from isocenter which results in geometric distortion. Multi-centered MRI can effectively correct the distortion. To minimize gradient nonlinearity-induced distortion, the center of each prescribed imaging volume shall be shifted to the isocenter of the magnet prior to acquisition (i.e., the region of highest gradient linearity). Following acquisition, images need to be corrected for gradient nonlinearity-induced distortion using the vendor-provided 3D distortion correction algorithm



## Summary and conclusions

In this session, we briefly reviewed the commonly employed MRI sequences and limitations related to radiation oncology. We further extended our discussion on MRI guidance in radiation oncology for selected anatomic sites.

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