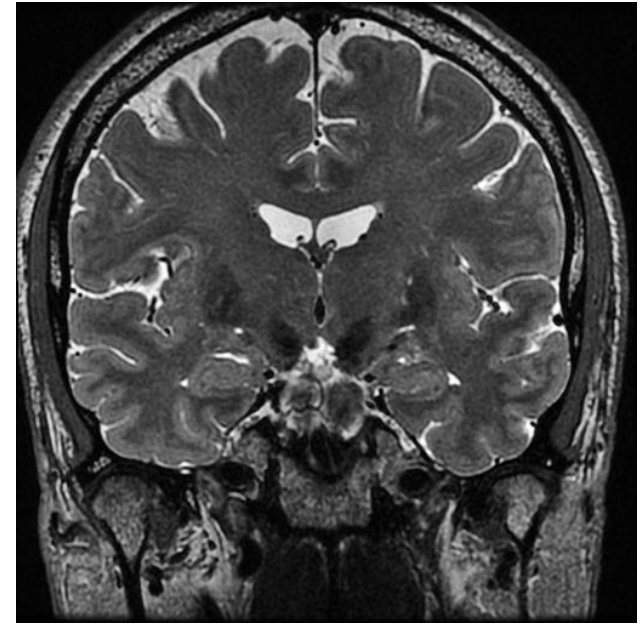
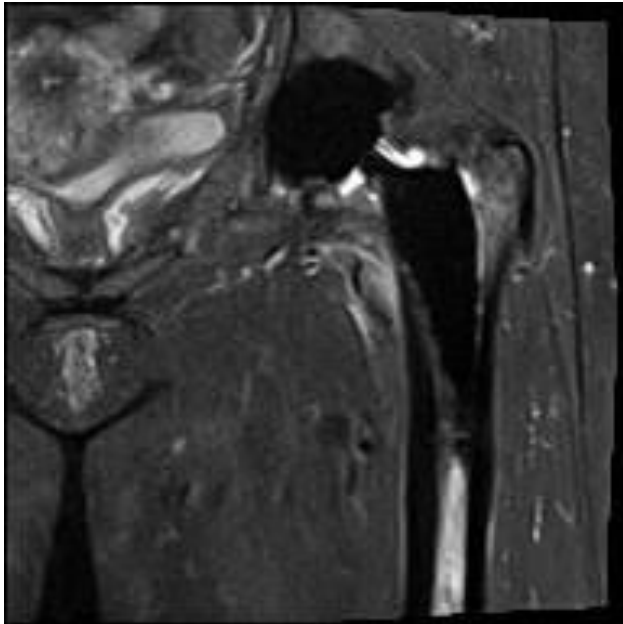


Magnetic Resonance Imaging

F.R.C.R. Physics Lectures



Lawrence Kenning PhD

Clinical Radiology

Curriculum 2021



Topic area	Main points
7. Magnetic resonance	<ul style="list-style-type: none">▪ Creation, detection and spatial localisation of the MR signal▪ Basic contrast mechanisms▪ Basic MRI sequences & common variants▪ Frequency-dependent techniques▪ T1-dependent techniques▪ Diffusion MRI▪ Acceleration techniques▪ Flow-related MR techniques▪ MR artefacts and artefact reduction techniques▪ MR safety▪ Quality assurance

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Guidance for the First FRCR Examination

https://www.rcr.ac.uk/sites/default/files/guidance_for_the_first_frcr_examination.pdf

7.1 Creation, detection and spatial localisation of MR signal

- Nuclear magnetic resonance
- Precession about magnetic fields (B_0 and B_1)
- Equilibrium magnetisation (M_0) and dependence on the strength of the magnetic field, B_0
- Longitudinal (M_z) and transverse magnetisation (M_{xy})
- Slice Selection
- k-space:
 - Relationship between k-space and MR image
 - Frequency-encoding
 - Phase-Encoding
 - Awareness of different k-space trajectories and their advantages/disadvantages
- 2D versus 3D sequences

7.2 Basic Contrast Mechanisms

- T_1 . Understand concept of MR signal saturation
- T_2 and T_2^*
- Impact of relaxivity of gadolinium-based contrast agents on T_1 -weighted and T_2^* weighted images
- Difference between a contrast-weighted MR image and a quantitative image (map)
- Extension of T_2^* -weighted MRI to susceptibility-weighted imaging (SWI)

7.3 Basic MRI sequences & common variants

- Spoiled gradient echo, spin echo
- Multiple echo variants (TSE/FSE, EPI)
- Single shot versus multi shot
- Pulse sequence diagrams
- Basics of steady-state sequences

7.4 Frequency-dependant techniques

- Understanding of chemical shift: fat&water
- Fat saturation
- In-phase & out-of-phase TEs, Dixon
- Awareness of MR spectroscopy (MRS) and appropriate TEs for particular clinical questions

7.5 T1-dependant techniques

- Inversion recovery (IR)
- Suppression: STIR & FLAIR. The role(s) of TR (and T_1) in determining null point.
- Increase T1-weighting e.g. MPRAGE
- Phase-sensitive IR

7.6 Diffusion MRI

- Diffusion weighting, relationship with underlying cellularity
- B-values, ADCs and calculated b-values
- Potential perfusion contribution to ADC
- Diffusion anisotropy.

7.7 Acceleration techniques, their impact on image quality and potential artefacts

- Zero-filling (interpolation)
- Half-Fourier
- Parallel imaging
- Simultaneous multislice (multiband)
- Compressed sensing
- Temporal sharing (TWIST/TRICKS)

7.8 Flow-related MR techniques

- Dynamic contrast-enhanced (DCE)
- Perfusion MRI
 - Dynamic susceptibility contrast (DSC)
 - Awareness of arterial spin labelling (ASL)
 - DCE for myocardial perfusion, oncology
- MR angiography (MRA) techniques,
 - Time of flight
 - Contrast-enhanced
 - Phase contrast
- Other non-contrast enhanced MRA options

7.9 MR artefacts and artefact reduction techniques

- Causes of potential solution for artefacts found in MRI, including:
- Motion artefacts, respiratory gating, navigated sequences, saturation bands, radial-type k-space acquisitions
- B0 inhomogeneities, e.g. air/tissue interfaces or metal implants
- B1 inhomogeneities especially at 3T
- RF interference: instantaneous (RF spikes); continuous RF interface
- Phase wrap
- Truncation artefact (Gibb's ringing)
- Chemical shift, receiver bandwidth
- Fat-water swaps in Dixon MRI
- Poor geometry-factor with high acceleration factors in parallel imaging

7.10 MR safety (Part 1)

- MHRA guidelines as the primary safety reference for UK
- MR safety framework, definitions, roles & responsibilities
 - MR Responsible Person and MR Safety Expert
 - MR Authorised Persons
 - MR Environment and MR Controlled Access Area
 - MR Safe / MR Conditional / MR Unsafe / MR Unlabelled
- Safety issues, particularly with regards to implanted devices and emergency situations, including
 - Attraction, torque
 - RF heating: SAR and B_{1+} rms
 - Magnetic quench

7.10 MR safety (Part 2)

- Safety issues associated with gadolinium-based contrast agents
 - Linear versus macrocyclic-based agents
 - Nephrogenic systemic fibrosis (NSF)
 - Gadolinium deposition/retention
- Recommendations for scanning patients with implanted devices without the manufacturer's approval, e.g. 'off label'

7.11 Quality assurance

- Importance of quality assurance in MR to identify failing elements in phased array coils
- Quality assurance to help establish reproducibility of quantitative MR techniques

Books

- MRI from Picture to Proton
- Farr's Physics for Medical Imaging
- Webb's Physics of Medical Imaging
- MRI in Practice

Websites

- <https://radiologylearninglondon.com/physics/frcr-part-1-physics-syllabus/>
- <http://mriquestions.com>
- <http://www.revisemri.com>
- <http://www.mrisafety.com>
- <https://www.gov.uk/government/publications/safety-guidelines-for-magnetic-resonance-imaging-equipment-in-clinical-use>