جامعة المستقبل
كلية التقنيات الصحية والطبية
قسم تقنيات البصريات

Fourth Stage 2024-2025

X-ray and Ultrasound of The Eye

Lecture Title

INTRODUCTION TO MAGNETIC RESONANCE IMAGING

Lecture Number: 7

Prepared by

Hassan A. Aljaberi

OPTOMETRIST

Introduction to MRI of the Orbit

Purpose and Importance of MRI for Orbital Imaging

- **High Soft-Tissue Contrast:** MRI provides high-resolution images that differentiate between various soft tissues, making it highly suitable for examining the complex structures of the orbit. Unlike CT, which is better for bone detail, MRI is excellent for soft tissue contrast.
- **Non-Invasive and Safe:** MRI doesn't involve ionizing radiation, making it safer for repeated imaging, which can be especially important for conditions that require follow-up.

Anatomy of the Orbit

- **Orbital Structures:** The orbit consists of the eyeball, optic nerve, extraocular muscles, fat, and surrounding connective tissues. MRI's ability to differentiate between these soft tissues is crucial for a clear assessment.
- **Optic Nerve and Muscles:** High-resolution MRI is ideal for observing the optic nerve, which is key in diagnosing conditions like optic neuritis or compressive optic neuropathy.
- **Fat Suppression Techniques:** Fat suppression MRI sequences are often used to minimize the signal from orbital fat, enhancing the visibility of lesions or inflammatory processes around the eye.

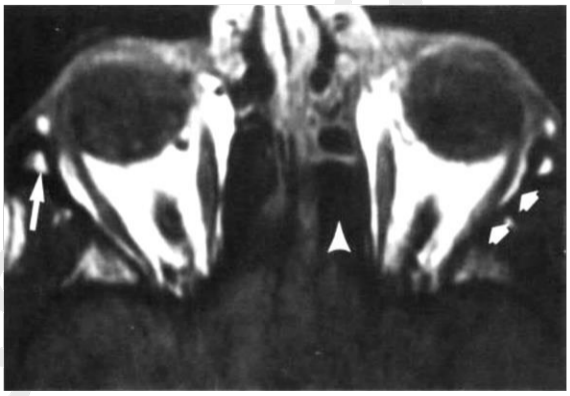
Common Indications for Orbital MRI

- **Inflammatory and Infectious Diseases:** Conditions like thyroid eye disease, orbital cellulitis, and inflammatory pseudotumor can be effectively visualized with MRI.

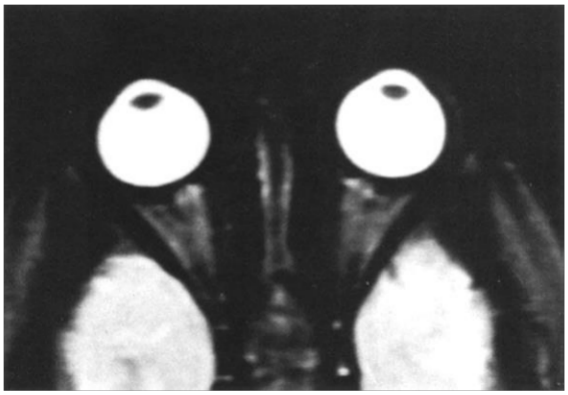
- **Tumors and Masses:** MRI helps in identifying and characterizing orbital tumors, such as optic nerve glioma, cavernous hemangioma, and lymphoma.
- **Vascular Anomalies:** MRI with specific sequences can evaluate vascular lesions, such as cavernous malformations or arteriovenous malformations, providing detailed information about blood flow and lesion structure.
- **Trauma:** Although CT is typically the first-line imaging for trauma due to its rapid acquisition and bone detail, MRI is valuable for evaluating the soft tissue effects of trauma, such as optic nerve damage.

Imaging Techniques and Protocols

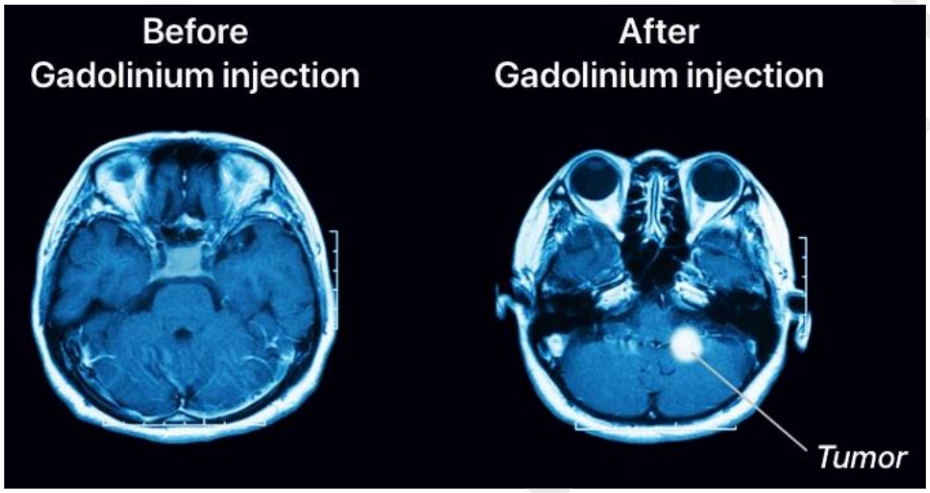
- **T1-Weighted Imaging:** T1-weighted images provide high anatomical detail, useful for evaluating the structure of the orbit and any contrast-enhancing lesions.



- **T2-Weighted Imaging:** These sequences highlight fluid-filled structures and pathology, helpful for identifying edematous or inflammatory changes.



- **Fat-Suppressed Sequences:** Fat suppression allows better visualization of abnormal tissue by reducing the high-intensity signal from orbital fat, making it easier to spot subtle lesions.
- **Post-Contrast Imaging (with Gadolinium):** Contrast-enhanced MRI is valuable in identifying active disease, such as inflammation or neoplasms, as they enhance with gadolinium.



The working principles of MRI (Magnetic Resonance Imaging)

1. Strong Magnetic Field

- MRI begins with a strong magnetic field, usually from a large superconducting magnet. This field aligns the magnetic moments of hydrogen protons (found abundantly in the body's water and fat) in the direction of the magnetic field.

2. Radiofrequency (RF) Pulse and Resonance

- An RF pulse, tuned to the frequency of hydrogen atoms, is briefly applied perpendicular to the magnetic field. This pulse disturbs the alignment of the protons, causing them to move to a higher energy state.

- When the RF pulse is switched off, the protons relax back to their original alignment, releasing energy in the process. This phenomenon is known as resonance, and it produces a signal that MRI sensors can detect.

3. Relaxation Times (T1 and T2)

- T1 Relaxation (Longitudinal Relaxation): This is the time it takes for protons to realign with the magnetic field. T1-weighted images are good for showing anatomical detail and are used in contrast-enhanced imaging.
- T2 Relaxation (Transverse Relaxation): T2 relaxation measures how quickly protons lose coherence in the transverse plane. T2-weighted images highlight fluids and are helpful in identifying edema, inflammation, and other pathological changes.

4. Signal Detection and Gradient Coils

- Gradient coils are used to vary the magnetic field strength across different axes (X, Y, and Z), allowing spatial localization of the MRI signal. This makes it possible to construct 2D or 3D images of specific areas within the body.
- The MRI machine detects the energy released during proton relaxation as an electrical signal, which is then processed to generate images.

5. Image Reconstruction

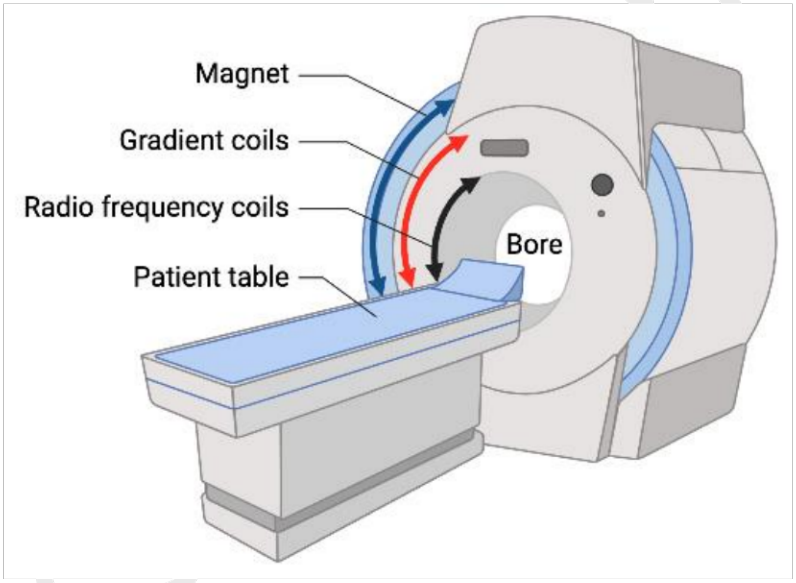
The collected signals are processed using advanced algorithms to produce detailed cross-sectional images. The contrast in these images depends on the type of tissue, the concentration of hydrogen atoms, and the relaxation times.

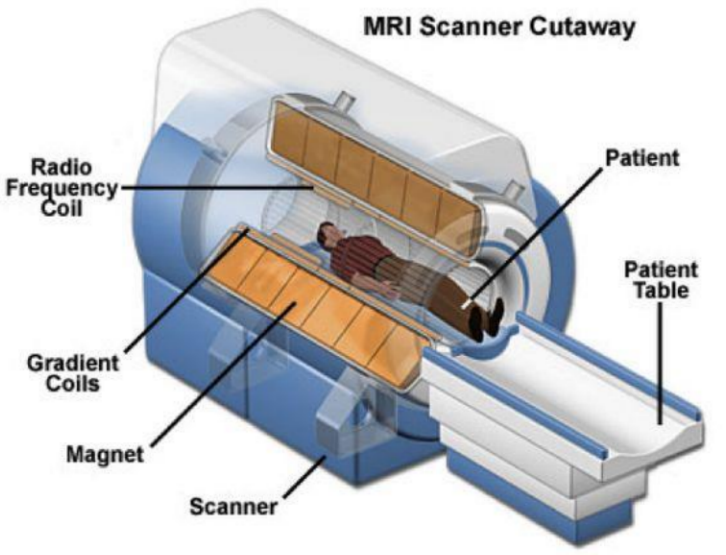
6. MRI Contrast Agents

For enhanced imaging, especially in specific tissues or tumors, a gadolinium-based contrast agent may be injected. This contrast agent alters the local magnetic field, improving the visibility of certain tissues or abnormalities.

The main components of an MRI (Magnetic Resonance Imaging)

- **Main Magnet:** Generates the magnetic field.
- **Gradient Coils:** Provide spatial encoding for image formation.
- **RF Coils:** Transmit and receive signals from the body.
- **Computer System and Software:** Control the machine and process images.
- **Patient Table:** Positions and supports the patient.
- **Magnet Cooling System:** Maintains low temperatures for superconducting magnets.
- **Control Room:** Allows safe monitoring and operation by the MRI technologist.





Advantages of MRI

1. Excellent Soft Tissue Contrast
2. No Ionizing Radiation
3. Detailed Anatomical and Functional Imaging
4. Multiplanar Imaging
5. Non-Invasive
6. Versatility in Imaging Techniques

Disadvantages of MRI

1. Longer Scan Time
2. High Cost
3. Claustrophobia and Patient Discomfort
4. Not Suitable for Patients with Certain Implants
5. Limited Availability in Emergency Settings
6. Potential for Artifacts and Motion Sensitivity
7. Challenges with Bone Imaging