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Radiographers' Journal

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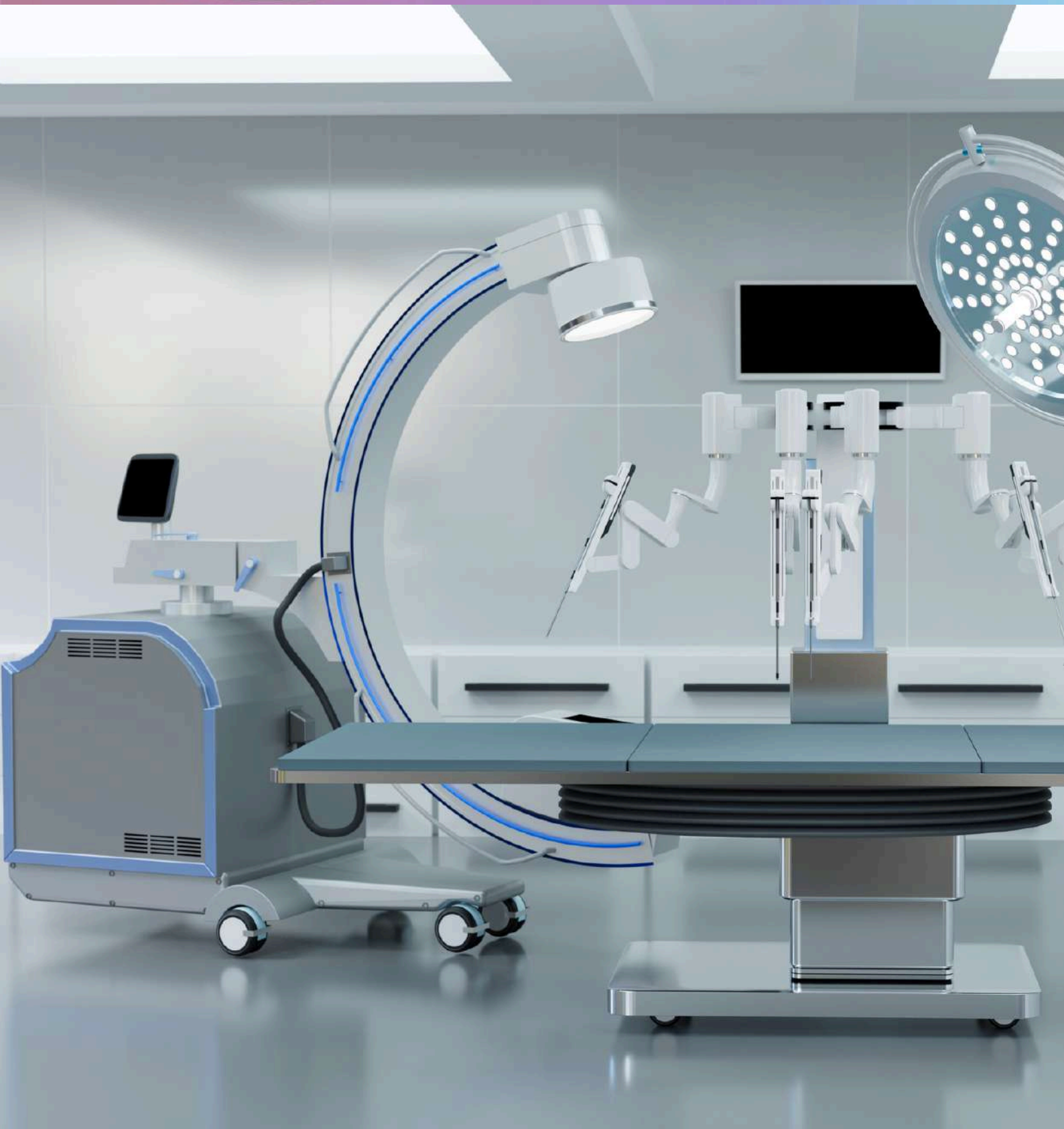


Editorial

Shankar K. Bhagat
Editor-in-chief

Dear Readers,

As we bring you the October 2025 edition of the Radiographers Journal, we proudly present a thoughtfully curated collection of articles that reflect the evolving knowledge, responsibilities, and technical advancements in radiographic practice. This issue brings together diverse topics ranging from contrast media and breast imaging to neuro-MRI and patient safety, offering readers a practical and academic blend of insights.

We begin with "Contrast Media and Their Types in Radiography," a foundational yet highly relevant article that revisits the principles and applications of contrast agents across modalities. The contributors explain iodine-based, gadolinium-based, and emerging nanoparticle agents, highlighting their mechanisms, selection criteria, and safety considerations. For both trainees and practicing radiographers, this article reinforces the importance of contrast optimization in enhancing diagnostic accuracy.

Following this, "MRI Contrast Agents Based on Protein-Targeted Gadolinium: Structure, Workings, and Uses" delves into a niche yet rapidly growing segment of MRI contrast science. The authors illustrate how targeted gadolinium complexes improve specificity, reduce systemic exposure, and open up new avenues in oncologic and neurological imaging. The discussion on molecular structure and mechanism broadens readers' appreciation for innovation in safety and precision.

Safety is further emphasized in the next contribution, "Safe MRI Practice in Patients with Suspected Intraocular Foreign Bodies (IOFB): UK Experience and Practical Guidance for Radiographers." Drawing from UK-based clinical protocols, the article offers practical steps for pre-screening, collaboration with ophthalmic teams, localized imaging, and decision-making to avoid catastrophic risks. It reinforces radiographers' crucial role in balancing diagnostic need and patient protection.

Shifting to neuroimaging research, "Unveiling the Role of the Subiculum in Scene Perceptual Discrimination: Insights from Ultra-High-Field fMRI" presents a compelling look at the subiculum's functional role within the hippocampal formation. Using ultra-high-field MRI, the article highlights the advancements in visualizing microstructural brain regions. Radiographers will gain valuable perspective on how emerging technology is redefining both research applications and future clinical protocols.

The issue then explores a broader clinical domain with "A Review Article on the Advancements in Abdominal MRI." This piece summarizes progress in sequence innovation, motion correction, diffusion imaging, and functional assessments. It underscores how evolving abdominal MRI techniques are replacing more invasive diagnostic procedures while offering enhanced clarity for liver, pancreatic, and gastrointestinal pathologies.

Progress in women's imaging takes center stage in "3D Mammography (Tomosynthesis): A New Era in Breast Cancer Screening." The article contrasts tomosynthesis with traditional 2D mammography, emphasizing improved visualization in dense tissue, decreased recall rates, early lesion detection, and practical considerations in workflow and positioning. Radiographers will find guidance relevant to both screening programs and diagnostic follow-up.

Finally, "Role of MRI in Detecting Rabies and Viral Encephalitis: A Mini Review" brings attention to rare but critical conditions. The authors summarize key MRI findings in viral encephalitic presentations, stressing MRI's role in timely diagnosis and prognostic assessment. This article is particularly valuable for those involved in emergency, neurological, and infectious disease imaging, where rapid interpretation can impact outcomes.

Collectively, this issue demonstrates the breadth of the radiography profession—where scientific innovation, clinical safety, imaging technology, and research converge. We extend our sincere appreciation to all contributors whose expertise shapes each page. We encourage our readers to engage deeply with these articles, apply their learning in practice, and continue striving for excellence in patient care and imaging science.

With every edition, the Radiographers Journal reaffirms its commitment to education, collaboration, and progressive practice. We look forward to your continued readership, feedback, and scholarly participation.

KASTURBA MEDICAL COLLEGE
MANGALORE
(A constituent unit of MAHE, Manipal)

23RD NATIONAL CONFERENCE OF SOCIETY OF INDIAN RADIOGRAPHERS

IMAGINE

in association with

Society of Indian Radiographers
Karnataka Medical Radiographers and Allied Technologists Association
Karnataka State Government Radiology Imaging Officers Central Association

HOST: *Department of Radiodiagnosis and Imaging, Kasturba Medical College, Mangalore*

THEME: *Advancing Frontiers: Ushering in a New Era of Medical Imaging*

31st October - 2nd November 2025 | **TMA Pai Convention Centre, Mangalore**

WELCOME Message

Namaskara from Mangaluru,

We are delighted to extend a warm welcome for the 23rd National Conference of Society of Indian Radiographers – IMAGINE 2025, in association with Karnataka Medical Radiographers and Allied Technologist Association and Karnataka State Government Radiology Imaging Officers Central Association, hosted by the Department of Radiodiagnosis and Imaging, Kasturba Medical College, Mangalore (unit of Manipal Academy of Higher Education).

IMAGINE 2025 brings together leading researchers, clinical experts, industry pioneers, and aspiring professionals to explore the latest innovations, share groundbreaking research, and foster collaboration in the dynamic field of medical imaging.

The theme, ***"Advancing Frontiers: Ushering in a New Era of Medical Imaging,"*** the conference will spotlight cutting-edge technologies, transformative ideas, and emerging trends shaping the future of healthcare. It's an opportunity to engage in thought-provoking discussions, attend insightful keynote sessions, and participate in interactive workshops.

Whether you are an academic, healthcare professional, student, or industry partner, IMAGINE 2025 offers a platform to connect, learn, and inspire innovation.

kmicon2025.com

We welcome you to Mangalore – the coastal city, the educational hub and famous for its cuisine, beaches and temples. Join us as we push the boundaries of medical imaging technology and drive progress in healthcare.

Organizing Committee...

Registration details (fees in rupees)			
#	Category	From 11th July 2025 to 31st August 2025	Spot Registration
1	Students (BSc, MSc)	Rs. 2,000/-	Rs. 5,000/-
2	Members of SIR, KMRATA, KSGRIOCA (Faculty & PhD)	Rs. 3,000/-	Rs. 5,000/-
3	Non-Members of SIR, KMRATA, KSGRIOCA (Faculty & PhD)	Rs. 3,500/-	Rs. 5,000/-
4	Members of SIR, KMRATA, KSGRIOCA (Technologist)	Rs. 3,000/-	Rs. 5,000/-
5	Non-Members of SIR, KMRATA, KSGRIOCA (Technologist)	Rs. 3,500/-	Rs. 5,000/-
6	Radiology Faculty	Rs. 4,000/-	Rs. 5,000/-
7	Radiology PG's	Rs. 3,500/-	Rs. 5,000/-
8	Accompany	Rs. 3,000/-	Rs. 5,000/-
9	Retired Technologist	Rs. 3,000/-	Rs. 5,000/-
***GST is applicable**			
***Cancellation policy: 50% refund till one month of the event**			

Registration fee includes entry to all scientific sessions, entry to trade expo, delegate kit (laptop bag) and electronic ID, all meals for all days, entry to musical night, access to scientific material, opportunity to submit abstract for scientific competition and credit points with certificate.

Contrast Media and Their Types in Radiography

Firdous Nazir, Radiographic Technologist, DMST, Pulwama, Jammu & Kashmir

Radiography has transformed medical diagnosis by offering clear and accurate imaging of internal structures. Yet, some regions of the body remain difficult to visualize because soft tissues absorb X-rays in a similar way. This is where contrast media (CM) play an essential role. By altering the contrast between structures, these agents highlight anatomy and pathology, making hidden details visible.

In 2025, with advancements in material science, safety protocols, and imaging technology, the understanding and use of contrast media have evolved significantly

What is Contrast Media?

Contrast media are substances introduced into the body to increase the visibility of internal organs, blood vessels, or tissues during medical imaging. They work by altering the attenuation of X-rays (or other radiation like ultrasound and MRI), creating differences in density that appear as contrast on images.

Key purposes:

- Enhance diagnostic accuracy.
- Distinguish normal from abnormal structures.
- Allow dynamic studies like blood flow and organ function.
- Reduce misinterpretation of subtle pathologies.

Ideal Properties of a Contrast Medium

For a contrast medium to be effective and safe, it must have:

- High X-ray attenuation.
- Low toxicity.
- Minimal allergic potential.
- Rapid excretion.
- Chemical stability.
- Cost-effectiveness.
- Compatibility with imaging equipment.

Modern research in 2025 focuses on developing agents with nanoparticle technology for better image quality and bio-degradable compounds to reduce renal stress.

Classification of Contrast Media in Radiography

Contrast agents are broadly divided into positive and negative types, based on their radiographic appearance.

1. Positive Contrast Media

These absorb more X-rays than surrounding tissues, appearing white or radiopaque on images.

Iodine-based agents

Water-soluble: Used in angiography, urography, CT contrast.

Oil-based: Rarely used today, except in specialized procedures like sialography.

Types: Ionic and Non-ionic.

1. Ionic (older, hyperosmolar, higher risk of side effects).
2. Non-ionic (modern, low-osmolar, safer, widely used in 2025).

Barium sulfate

- Used in gastrointestinal imaging.
- Excellent mucosal coating.
- Not absorbed systemically.
- Now available in nano-suspension formulations in 2025, reducing clumping and improving coating uniformity.

2. Negative Contrast Media

These absorb fewer X-rays than surrounding tissues, appearing black or radiolucent.

Examples: Air, carbon dioxide, oxygen.

- Used in double-contrast studies with barium, highlighting mucosal folds.
- Carbon dioxide is preferred over room air for vascular studies due to reduced embolism risk.

3. Dual/Double Contrast Technique

Combines both types for maximum detail. For example:

- Barium + air in double-contrast barium enema.
- Provides detailed mucosal surface visualization.

Routes of Administration

Contrast media are introduced based on the imaging requirement:

- **Oral:** Barium or iodine for GI tract.
- **Intravenous (IV):** Iodine for CT, angiography.
- **Intra-arterial:** For angiographic studies.
- **Intrathecal:** For myelography using non-ionic iodine agents.
- **Rectal:** For lower GI tract.
- **Intra-cavitary:** For hysterosalpingography, cystography.

Mechanism of Action

- **Barium sulfate:** Coats mucosal surfaces, outlining the lumen.

- **Iodine-based agents:** Iodine's high atomic number (Z=53) increases X-ray absorption, enhancing vessel and organ visualization.
- **Negative agents (air, CO_2):** Create contrast by reducing X-ray absorption in filled cavities.

Clinical Applications

Gastrointestinal Imaging

- Barium swallow, meal, enema.
- Double contrast enhances mucosal pathology like ulcers, tumors, and polyps.

Vascular Imaging

- Iodinated IV agents in angiography, CT angiography.
- Carbon dioxide as an alternative in patients with renal impairment.

Urogenital Studies

- Intravenous urography, cystography, retrograde pyelography.

Spinal Imaging

- Myelography with water-soluble non-ionic iodine.

Interventional Radiology

- Contrast agents guide catheter placement, embolization, stent placement.

Adverse Reactions to Contrast Media

Despite improvements, contrast media can cause side effects.

Minor reactions

- Nausea, vomiting, flushing, metallic taste.
- Mild urticaria.

Moderate reactions

- Hypotension, bronchospasm.
- Angioedema.

Severe (rare but life-threatening)

- Anaphylaxis.
- Cardiovascular collapse.
- Seizures in intrathecal use.

Risk factors: Asthma, history of allergies, renal impairment, dehydration.

In 2025, AI-based risk stratification tools integrated into radiology workflow can predict high-risk patients before administration.

Contrast-Induced Nephropathy (CIN)

One of the most concerning complications is renal impairment after iodinated contrast exposure. CIN is defined as a rise in serum creatinine within 48–72 hours post-injection.

Prevention strategies (2025 standards):

- Pre-hydration protocols.
- Use of low-osmolar or iso-osmolar non-ionic agents.
- Monitoring kidney function with AI-predicted GFR algorithms.
- Use of nanoparticle-based iodine carriers that clear faster and with less renal load.

Advances in Contrast Media Technology (2025 Update)

Dual-Energy CT and Spectral Imaging

- Differentiate contrast agents from calcium and hemorrhage.
- Use less contrast volume with improved sensitivity.

Microbubble Contrast Agent

- Already standard in ultrasound.
- Now tested for hybrid use in X-ray-based techniques for vascular imaging research.

Molecular Imaging Contrast

- Iodine nanoparticles tagged with specific biomarkers.
- Targeted imaging of tumors with higher accuracy.

AI-Optimized Protocols

- Automated contrast dose calculation based on body habitus and renal function.
- Prevents overdosing, reduces waste.

Eco-friendly Contrast Media

- Focus on reducing environmental burden of gadolinium and iodine excretion into water systems.
- Biodegradable agents under clinical trial in 2025.

Contrast Media in Specialized Modalities

CT Scan: Uses non-ionic iodinated agents.

Digital Subtraction Angiography (DSA): Iodine or CO_2.

Interventional Procedures: Targeted injections with minimal volumes.

Hybrid Imaging (PET/CT, SPECT/CT): Trials of dual-function contrast that combine diagnostic imaging with molecular targeting.

Best Practices for Radiographers in 2025

- Screen patients for allergies, renal function, and comorbidities.
- Use AI-supported dose calculation systems.
- Be prepared with emergency drugs (adrenaline, antihistamines, corticosteroids).
- Ensure post-procedure monitoring, especially in high-risk patients.
- Adopt eco-friendly disposal of leftover contrast media.
- Future Outlook

The future of contrast media in radiography points toward:

Personalized contrast dosing based on patient genomics.

- Nanoparticle-based smart agents that selectively bind to pathology.
- Integration with AI diagnostics for precision medicine.
- Sustainable practices reducing environmental impact.

Conclusion

Contrast media remain central to radiology by enabling visualization of anatomy and pathology that plain radiographs cannot reveal. The journey from traditional barium and ionic iodine to today's non-ionic, nanoparticle-enhanced, AI-guided agents reflects tremendous progress. In 2025, safety, efficiency, and eco-friendliness dominate the research agenda. For radiographers and clinicians, mastering the knowledge of contrast types, applications, risks, and evolving technology is essential to deliver high-quality, patient-centered imaging services.

QUIZ to Recapitulate

Pawan Kumar Popli, Chief Technical officer-Radiology (Retd.), AIIMS, New Delhi

1. In case of non availability of Non ionic Contrast medium which contrast medium can be used to study TEF?

2. Explain the tube angulation for radiography of male bladder- AP view.

3. What is the use of exchange guide wire in angiography?

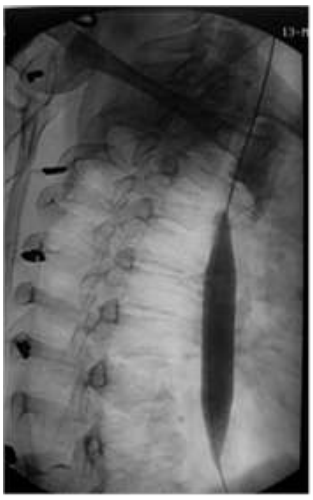
4. Why is shimmimg done in MRI?

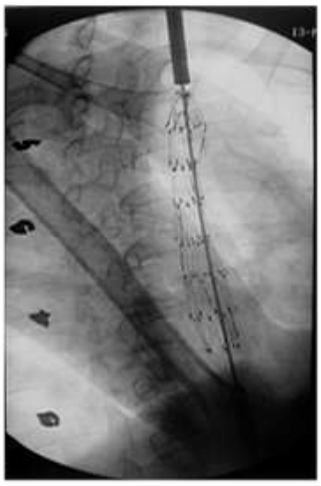
5. What is recommended FFD for conventional High KV technique in chest radiography?

6. What is the vertical angulation for IOPA for lower canine of an adult?

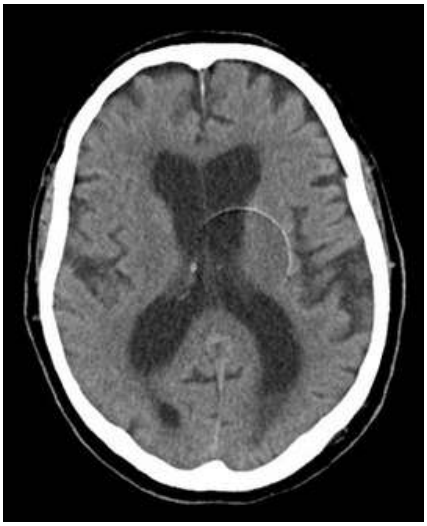
7. What is missed cycle rule in radiation protection?

8. Identify the procedure

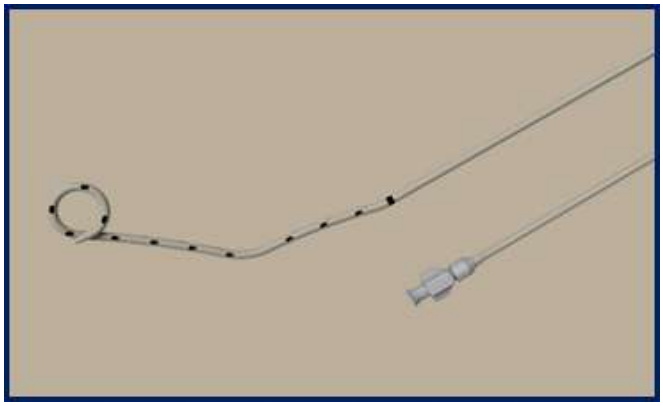




9. Identify the problem and suggest the primary action to be taken by Radiographer



10. Identify the object



- Please send your answers through email on **pkpopli@gmail.com** on or before **10th November 2025.**
- Send your **Name with Hospital/Institution Information** and Passport size **photograph** along with the answers.
- **Best 3 participants** (early birds and correct) in each month will get the prizes **(Sponsored by JBD Publications).**
- Correct answers will be published in the next issue.
- If required /requested by participants more details about any question can be provided in upcoming issues under title **"Your Requests"**

Answers for the Quiz - September 2025 issue

1. Atomic Energy Regulatory Board (AERB)

2. Bronchography

3. As oral contrast agent to optimally distend (expand) the small bowel.

4. RF shielded glass – Made of Glass with embedded copper or conductive mesh to prevent RF interference in Gantry room.

5. It should be the Minimum possible distance.

6. Size 2 , 30.5mm x 40.5mm

7. Caldwell view

8. Heel lateral for heel pad thickness for Acromegaly

9. Heel lateral for calcaneal spur

10. Lateral invertogram to assess anal/ rectal atresia/congenital anorectal anomaly.

The following readers participated in the Quiz – September 2025 issue.

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MRI Contrast Agents Based on Protein-Targeted Gadolinium: Structure, Workings, and Uses

Pratik Virat, Bharvi Joshi M. Sc. Research fellows, **Mamta Verma, Raushan Kumar,** Assistant Professors,
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Abstract

Protein-targeted gadolinium-based MRI contrast agents are a state-of-the-art development in medical imaging. By selectively attaching to specific proteins within the body, these compounds are intended to improve the visibility of particular tissues or organs during an MRI scan. In terms of structure, they are made up of a protein-targeting moiety, which is a molecule made to attach to a particular protein, and a gadolinium chelate, which is a molecule that contains gadolinium ions for contrast enhancement.

The protein-targeting moiety directs the contrast agent to the appropriate protein inside the body as part of the mechanism of action. After binding, the gadolinium chelate accumulates in the targeted region, improving the MRI image's contrast. This targeted strategy has enormous potential for a number of uses, such as better tumor imaging by focusing on proteins unique to cancer cells, better inflammatory disease diagnosis and monitoring by focusing on inflammation-related proteins, and more accurate blood clot detection by focusing on blood clotting-related proteins.

Protein-targeted gadolinium contrast agents are still in the research and development stage, but they hold out the potential of more accurate and informative MRI scans, which could result in earlier and more accurate diagnoses as well as more individualized treatment plans. They do, however, come with possible hazards and adverse effects, like allergic responses or, in rare instances, nephrogenic systemic fibrosis in people with kidney issues, much like any other medical operation. As a result, the possible advantages of using these contrast agents should be carefully evaluated.

Keywords: Targeted MRI contrast agents, Protein-targeted MRI, Gadolinium contrast agents, Molecular MRI, Antibody-targeted MRI, Peptide-targeted MRI, Relaxivity, Molecular imaging, Disease-specific targets (e.g., "EGFR MRI contrast," "amyloid MRI contrast")

Introduction

Because it provides high-resolution, non-invasive anatomical and functional imaging, magnetic resonance imaging (MRI) has emerged as a key component of contemporary medical diagnosis. However, the sensitivity and specificity needed for early illness diagnosis and accurate molecular-level characterisation of pathological processes are frequently lacking in conventional MRI. This restriction has prompted the creation of targeted contrast agents, especially those based on protein-targeted gadolinium (Gd), which mark a substantial advancement in molecular imaging. These substances are designed to connect to particular proteins that are linked to a number of illnesses, making it possible to see molecular signatures and offering vital information that goes beyond conventional anatomical data. Although they are good at highlighting vascular structures and regions with higher vascular permeability, conventional Gd-based contrast agents are unable to differentiate between various disease states using molecular markers. Their diagnostic value is limited by this lack of specificity, particularly in early-stage disorders when minute molecular changes occur before macroscopic anatomical abnormalities. By adding a targeting moiety—such as an antibody, peptide, or other ligand—that selectively identifies and binds to a target protein of interest, protein-targeted Gd-based therapies overcome this restriction. Enhanced sensitivity by focusing the contrast agent at the disease site, improved specificity by binding to disease-associated proteins selectively, and the possibility of earlier disease detection by observing molecular changes prior to significant tissue damage are some of the main benefits of this targeted approach. Three essential elements are usually included in the design of these agents: a targeting moiety to guarantee precise binding to the target protein, a linker to join the two, and a Gd chelate to supply the paramagnetic qualities for MRI contrast. By choosing the right targeting moieties for various disease targets, this modular design enables flexibility in customizing the contrast agent to particular applications. The complexities of this design, the ways in which these agents improve MRI contrast, and their wide range of medical applications —highlighting their potential to revolutionize disease diagnosis, monitoring, and treatment approaches—will all be covered in detail in the sections that follow.

Gadolinium chelates

The source of the paramagnetic qualities that improve image contrast in protein-targeted MRI contrast agents is the gadolinium (Gd) chelate. Due to its seven unpaired electrons, the rare earth metal gadolinium is strongly paramagnetic and can effectively reduce the relaxation periods of surrounding water protons. T1-weighted MRI images provide a stronger signal as a result of this shortening, making tissues and organs more visible. However, the human organism is extremely poisoned by free Gd^{3+} ions. A stable complex known as a gadolinium chelate is created when gadolinium is attached to a chelating agent in order to lessen its toxicity. By encasing the Gd^{3+} ion, the chelating agent stops it from interacting with biological molecules and producing negative effects.

A number of chelating agents are frequently found in MRI contrast agents, such as:

1.Diethylenetriamine pentaacetic acid, or DTPA, is a linear chelating agent that combines with Gd^{3+} to produce a stable complex.

2.Compared to DTPA, DOTA (1,4,7,10-tetraazacyclododecane -1,4,7,10-tetraacetic acid) is a cyclic chelating agent that gives the Gd^{3+} complex more kinetic inertness and thermodynamic stability.
3. A DOTA derivative with one fewer acetate group, DO3A (1,4,7,10-tetraazacyclododecane-1,4,7-triacetic acid) is frequently utilized as a building block for the creation of more intricate contrast agents.

The Gd chelate's stability, relaxivity (the capacity to improve water proton relaxation), and overall safety profile can all be impacted by the chelating agent selection. In order to maximize the effectiveness and safety of Gd-based MRI contrast agents, researchers are still investigating novel chelating agents and chelate patterns.

Relaxivity

The ability of an MRI contrast agent to increase the relaxation rates of surrounding water protons is measured by its relaxivity, which is a crucial indicator of its efficacy. Water protons that have been excited and then relaxed back to equilibrium are the source of the MRI signal. A stronger signal results from the acceleration of this relaxation, especially T1 (longitudinal relaxation), by paramagnetic materials such as gadolinium. In particular, relaxivity (r1 and r2) indicates the rise in relaxation rate (1/T1 or 1/T2) for every unit of contrast agent concentration. Greater signal amplification for a given concentration is indicated by a higher relaxivity, which is preferable because it enables lower doses, potentially lowering toxicity. Temperature, the molecular makeup of the contrast agent, and the strength of the magnetic field produced by the MRI scanner all affect this feature.

Protein binding and relaxivity

In order to modify the relaxivity of gadolinium (Gd)-based MRI contrast agents, protein binding is essential. The molecular mobility of a contrast agent has a major impact on relaxivity, which is the effectiveness with which the chemical increases water proton relaxation and, consequently, picture brightness. A free Gd chelate in solution tumbles quickly, reducing the amount of time that water molecules and the paramagnetic Gd ion can interact. The relaxivity is decreased by this quick tumble.
However, because the protein is substantially larger, the Gd chelate's overall molecular motion is greatly slowed down when it binds to it. Because of this limited motion, water molecules near the Gd ion have a longer residence period, which promotes more effective relaxing and a significant rise in relaxivity. When it comes to tailored contrast agents, this phenomenon is especially pertinent since binding to the target protein at the disease site not only concentrates the agent locally but also improves its capacity to generate contrast. A brighter signal on MRI scans results from the enhanced relaxivity upon binding, enhancing the imaging method's sensitivity and diagnostic precision. A crucial design factor in the creation of high-performance tailored MRI contrast agents is this idea.

Relaxivity-influencing variables (hydration number, molecular tumbling rate, etc.)

Many important aspects of the contrast agent's molecular makeup and interactions with water molecules affect relaxivity, or how well it enhances the MRI signal.
Hydration number (q): This is the quantity of water molecules in the chelate that are directly coordinated to the gadolinium ion. Since more water molecules can directly interact with the paramagnetic Gd ion, a higher hydration number typically results in improved relaxivity. A balance is necessary since raising q can occasionally cause the chelate to become unstable.
Molecular tumbling rate (τr): This explains how the contrast agent molecule rotates in solution. Higher relaxivity results from slower tumbling, which is frequently accomplished by adhering to bigger molecules like proteins. This lengthens the period that water protons and Gd interact.
Water exchange rate: This is the rate of exchange between bulk water and water molecules in the inner coordination sphere of Gd. In order to effectively promote relaxation, the exchange rate must be at its ideal level; if it is too slow, the interaction with water is limited, and if it is too quick, the interaction is too short.
Electronic relaxation: This has to do with the electron spin relaxation of the Gd ion, which affects how well energy is transferred to water protons.
Magnetic field strength: The MRI scanner's magnetic field strength affects relaxivity as well.

These variables affect relaxivity in intricate ways and are interrelated. Developing high-performance MRI contrast agents requires careful molecular design to optimize these properties.

Targeting moiety

A protein-targeted MRI contrast agent's targeting moiety is its essential component that enables it to selectively attach to a certain molecular target, usually a protein, linked to a disease. A concentrated rise in gadolinium concentration and an improved MRI signal result from this selective binding, which guarantees the contrast agent accumulates at the place of interest. There are many different kinds of targeting moieties, such as aptamers, peptides, small compounds, and antibodies (or their components like Fab and scFv). Although they can be big and possibly immunogenic, antibodies have a high specificity and affinity. Although they are simpler to make and smaller, peptides may have a lesser affinity. Short DNA or RNA sequences called aptamers have a high affinity, are stable, and are simple to synthesize. Small molecules may have lesser selectivity even when they are easily produced and have good tissue penetration. The contrast agent's ability to achieve sensitive and accurate molecular imaging is ultimately determined by the targeting moiety's size, binding affinity, biocompatibility, and target expression levels in sick tissue.

Types of targeting moieties

Antibodies: The immune system produces proteins called antibodies, or immunoglobulins, which are known for their great affinity and specificity for target molecules, or antigens. Antibodies or their fragments (Fab, scFv) function as targeting moieties in tailored MRI contrast agents, allowing for selective binding to indicators linked to disease. The contrast agent accumulates locally as a result of this exact targeting, improving the MRI signal at the illness site. Although antibodies have high specificity, their size can prevent them from penetrating tissue, and their potential immunogenicity necessitates careful consideration in both clinical and design settings.
Peptides: Because of their tiny size, simplicity of synthesis, and lower immunogenicity than antibodies, peptides—short sequences of amino acids—are utilized as targeting moieties in MRI contrast agents. They can be made to bind particular target molecules, enzymes, or receptors. Peptides may have lesser binding affinity and specificity than bigger macromolecules like antibodies, despite their benefits in tissue penetration and cost-effectiveness; hence, careful design and optimization are necessary for efficient targeting.

Aptamers: Similar to antibodies, aptamers are short, single-stranded DNA or RNA oligonucleotides that may fold into distinctive three-dimensional structures and bind target molecules with high affinity and specificity. Aptamers have a number of benefits as targeting moieties in MRI contrast agents, including minimal immunogenicity, chemical stability, resistance to degradation (with modifications), and very simple and affordable synthesis. Better tissue penetration is also made possible by their lower size in comparison to antibodies. Even though chemical changes can increase their stability, their vulnerability to nuclease degradation in vivo is still a factor.

Small molecules: Because of their high tissue penetration and ease and affordability of production, small molecules—organic compounds with a low molecular weight—are used as targeting moieties in MRI contrast agents. They can be made to attach to particular biological targets, such as enzymes or receptors. Small molecules typically have lesser specificity and binding affinity than bigger macromolecules like antibodies or aptamers, despite having advantages in terms of manufacture and distribution. To increase their targeting efficiency, careful design and optimization are necessary because this can result in off-target binding and decreased contrast enhancement at the intended site.

Other targeting moieties: In addition to small molecules, aptamers, peptides, and antibodies, other compounds can function as targeting moieties in MRI contrast agents. Vitamins, such as folate, can be delivered precisely because they are actively carried into some cells, especially cancer cells. Because certain carbohydrate structures are recognized by cell surface receptors, they can also be used. These other targeting techniques have special benefits, such focusing on particular carbohydrate epitopes or taking use of cellular absorption mechanisms. Their binding affinity and specificity, however, can differ, necessitating a thorough assessment for every application.

Mechanism of action

The way protein-targeted gadolinium (Gd)-based MRI contrast agents work depends on a precisely planned series of actions that eventually result in improved image contrast at the target location. These substances enter the circulatory system and are dispersed throughout the body after being administered intravenously. The targeting moiety's precise binding to the matching target protein is the critical step. This targeting moiety, which may be a small molecule, aptamer, peptide, or antibody, is made to identify and bind to a molecular marker linked to a certain illness or condition with high affinity and specificity. This marker is frequently a protein that is either exclusively found in the impacted tissue microenvironment or overexpressed on sick cells. The contrast agent's localization at the illness site is started by this molecular recognition event.

The local concentration of gadolinium ions at the target site rises noticeably as a result of the targeting moiety's preferential binding to the target protein. The foundation of the contrast enhancement mechanism is this build-up. Due to their unpaired electrons, gadolinium ions produce a confined magnetic field, making them paramagnetic. The MRI signal originates from the relaxation characteristics of adjacent water protons, which are significantly impacted by this local magnetic field. In particular, the T1 relaxation time of water protons is shortened by gadolinium ions. When excited protons are disturbed by a radiofrequency pulse inside the MRI scanner, they revert to their equilibrium condition, a process known as T1 relaxation. This return to equilibrium is accelerated when gadolinium is present.

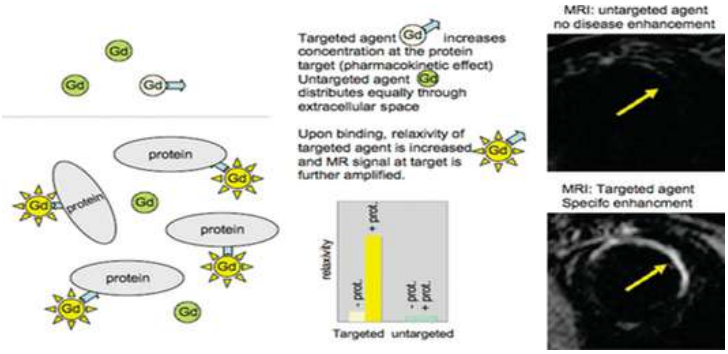

Figure 1 Mechanism of action

A stronger MRI signal coming from the targeted location is the result of this increased T1 relaxation. This results in the targeted tissue or region appearing brighter on the final pictures of T1-weighted imaging. The contrast between the surrounding background tissues and the targeted tissue, where the contrast agent has accumulated, is significantly increased by this increased signal strength. This enhanced contrast makes it easier to see and describe the illness or condition being studied.

Additionally, some sophisticated contrast agent designs include a responsive element, in which the contrast agent itself undergoes a conformational shift in response to the targeting moiety attaching to the target protein. This conformational shift has the potential to further alter the gadolinium chelate's relaxivity, which would increase the contrast effect and provide the imaging method an additional layer of sensitivity and specificity.

Applications:

Cancer imaging

Protein-targeted Gd-based magnetic resonance imaging contrast agents provide important benefits for early cancer detection, diagnosis, and treatment tracking. These medicines can particularly accumulate in tumor tissue by targeting angiogenesis indicators (like VEGF), growth factor receptors (like EGFR or HER2), or tumor-associated antigens (like CEA or PSMA). By improving MRI contrast, this focused accumulation makes it possible to identify small tumors, distinguish benign from malignant lesions, stage and grade cancers accurately, and track the exact effectiveness of treatments like radiation or chemotherapy. Additionally, this focused strategy facilitates image-guided surgery, which enables more accurate tumor excision

Cardiovascular imaging

Because they make it possible to see important pathological processes at the molecular level, protein-targeted Gd-based MRI contrast agents have enormous potential to improve cardiovascular imaging. The identification of susceptible plaques that are prone to rupture and subsequent thrombotic events is made possible by these agents' ability to target a variety of markers linked to cardiovascular illnesses, including inflammatory markers (VCAM-1, ICAM-1) expressed on activated endothelial cells in atherosclerotic plaques. Direct imaging of blood clots inside the heart or blood arteries is made possible by targeting thrombosis markers like fibrin or platelets. This helps with the diagnosis and treatment of diseases like pulmonary embolism and deep vein thrombosis. Additionally, during a myocardial infarction (heart attack), these substances can target myocardial damage signals like cardiac myosin or troponin, which are secreted from damaged heart muscle.

This makes it possible to precisely evaluate the extent of the infarct and the health of the surrounding tissue, which is essential for directing treatment strategies and forecasting patient outcomes. With regard to cardiovascular illness, this focused approach holds promise for early diagnosis, risk assessment, and individualized treatment plans.

Neurological imaging

Protein-targeted Gd-based MRI contrast agents have the ability to diagnose neurodegenerative disorders early and accurately in neurological imaging. These agents can visualize the molecular alterations linked to Alzheimer's disease and other tauopathies by focusing on important pathological hallmarks such as neurofibrillary tangles, which are aggregation of tau protein, and amyloid plaques, which are made of amyloid-beta peptide. Compared to traditional MRI, which usually only identifies structural alterations at a later stage, this enables earlier detection. Additionally, by analyzing changes in the amyloid and tau burden over time, these agents can be used to follow the development of the illness and assess the efficacy of therapeutic measures meant to lessen these pathological hallmarks. This focused strategy provides a potent instrument for improving our comprehension and treatment of neurodegenerative diseases.

Inflammation imaging

Gd-based MRI contrast agents that target proteins have great promise for identifying and detecting inflammation in a range of illnesses. These medicines can identify inflammation locations with great specificity by targeting particular markers implicated in the inflammatory process, such as adhesion molecules (integrins, selectins) that mediate leukocyte trafficking or signaling molecules like chemokines and cytokines. This makes it possible to image inflammatory diseases such as multiple sclerosis, rheumatoid arthritis, and inflammatory bowel disease, facilitating early diagnosis, evaluation of disease activity, and tracking of the effectiveness of anti-inflammatory treatments. Compared to traditional imaging methods, which frequently lack the sensitivity and specificity to identify modest inflammatory changes at an early stage, this tailored approach offers a considerable benefit.

Infectious disease imaging

By focusing on certain proteins found on the surface of pathogens such as bacteria, viruses, or fungus, protein-targeted Gd-based MRI contrast agents have the potential to enhance the imaging of infectious diseases. Compared to traditional imaging techniques, this tailored approach enables the identification and localization of infections with enhanced sensitivity and specificity. This can help with timely and effective treatment techniques, especially when identifying deep-seated infections or differentiating infections from sterile inflammation.

Gene therapy monitoring

By measuring the expression of therapeutic genes given to target cells, protein-targeted Gd-based MRI contrast agents can be extremely useful in gene therapy monitoring. Researchers can see the degree of gene expression in vivo and the success of gene transfer by using contrast agents that target the proteins encoded by these therapeutic genes. This makes it possible to evaluate the effectiveness of gene delivery, monitor treatment efficacy non-invasively, and optimize gene therapy regimens. This method helps create more efficient and focused gene therapies by offering insightful information on the spatiotemporal dynamics of gene expression.

Conclusion

An important development in molecular imaging is the use of protein-targeted gadolinium (Gd)-based MRI contrast agents, which have higher sensitivity and specificity than traditional agents. Because of their ability to bind selectively to particular proteins linked to disease, these agents allow for accurate monitoring, characterisation, and detection. The targeting moiety, the linker, and the Gd chelate are the three main parts of the design. The paramagnetic characteristics for enhancing MRI signals are provided by the Gd chelate, usually utilizing DTPA or DOTA. The chelating agent maximizes relaxivity while minimizing Gd^{3+} toxicity. Target specificity is determined by the targeting moiety, which might be tiny molecules, aptamers, peptides, or antibodies. Each has special benefits in terms of synthesis ease, size, and affinity. The linker affects flexibility, stability, and biodistribution by joining the targeted moiety and chelate.Local Gd build-up results from the mechanism's reliance on precise binding between the targeting moiety and the target protein. A stronger signal on T1-weighted imaging is the result of this rise in local Gd concentration, which also improves water proton relaxation. This targeted accumulation enhances contrast and makes it possible to see minute molecule changes, sometimes in conjunction with relaxivity modulation upon binding. These substances can be used to treat neurological disorders (targeting tau tangles and amyloid plaques), cardiovascular disease (targeting thrombosis, inflammation, and myocardial damage markers), cancer (targeting tumor antigens, receptors, and angiogenesis markers), and inflammation (targeting adhesion molecules, chemokines). Optimizing targeting, reducing non-specific accumulation, enhancing biocompatibility, and creating multimodal agents are the main areas of ongoing research that could transform illness diagnostics and individualized care.

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Safe MRI Practice in Patients with Suspected Intraocular Foreign Bodies (IOFB): UK Experience and Practical Guidance for Radiographers

Bharathkumar Karunagaran, Senior MRI Safety Radiographer NHS.

Abstract

Background: MRI is one of the safest and most advanced diagnostic imaging techniques, but for patients with metallic intraocular foreign bodies (IOFBs), it can present a serious hazard. Ferromagnetic fragments inside the orbit may move or heat under the influence of strong magnetic fields, risking permanent visual loss.

Aim: This article describes UK practice in the screening and management of suspected IOFBs, explains the radiographer's role in protecting patient safety, and provides practical workflow examples relevant to Indian practice.

Methods: A review of UK safety guidelines, published literature, and departmental practices is presented. A detailed radiographer-led screening and escalation pathway is outlined, with illustrative real-world examples.

Conclusion: Patient safety requires strict pre-scan screening, rapid access to orbital imaging, effective communication with radiologists and ophthalmologists, and comprehensive documentation. While this may delay scanning, these steps are essential to prevent irreversible harm.

Keywords: MRI safety, intraocular foreign body, radiographer, patient safety, ophthalmology referral

Introduction

Magnetic resonance imaging (MRI) is widely recognised as one of the safest imaging modalities because it does not use ionising radiation. However, its powerful static magnetic field, radiofrequency energy, and gradient switching create unique hazards when metallic foreign bodies are present. The eye is a critical site of concern. Even tiny ferromagnetic fragments can move or heat inside the orbit, causing intraocular bleeding, retinal detachment, or even blindness.

Intraocular foreign bodies (IOFBs) are most commonly associated with occupational exposure in industries such as welding, grinding, hammering, or working with machinery. In countries like India, where large numbers of patients are employed in metal-related industries, the risk of missed IOFBs is significant.

UK safety authorities — including the Medicines and Healthcare products Regulatory Agency (MHRA) and professional organisations such as the Society of Radiographers (SoR) and Royal College of Radiologists (RCR) — clearly state that MRI is contraindicated until a metallic IOFB is excluded. Radiographers are responsible for initial screening and are the first line of defence in ensuring patient safety.

Radiographer's Role in Screening and Safety

Initial referral Check

When an MRI request arrives, the radiographer should check the referral form for:

- History of trauma to the eye or orbit.
- Occupations involving metal exposure (welding, grinding, machining).
- Previous ocular surgery.

Patient Verbal Screening

At the MRI safety interview, radiographers must ask direct ocular questions:

- Have you ever injured your eye with metal or glass?
- Have you ever worked with welding, grinding, or hammering metal?
- Did you ever have metal removed from your eye in the past?

Escalation to Radiologist

If uncertainty exists, the radiographer must escalate immediately. The radiologist then decides on further investigations, usually beginning with an orbital X-ray.

Immediate orbital X-ray

- Negative X-ray: MRI may proceed safely.
- Positive X-ray: Patient cannot enter MRI. Referral to ophthalmology is mandatory.

Ophthalmology Pathway

If a metallic fragment is confirmed, the patient is referred by the requesting clinician to ophthalmology. The ophthalmologist assesses whether the fragment should be surgically removed. Only after removal and documented clearance can MRI be performed.

Real-Life Clinical Example

As a radiographer, I frequently encountered welders who were unsure about ocular injuries. In such cases, I followed a clear protocol:

1. Stop the MRI pathway immediately.
2. Contact the radiologist and explain the history.
3. Arrange orbital X-rays.
4. Await immediate reporting.
5. If negative → proceed to MRI the same day.
6. If positive → inform the patient and referring clinician.

The patient is then redirected to ophthalmology.

This workflow ensures no patient with a possible metallic IOFB enters the MRI scanner without clearance. While it sometimes causes patient frustration due to delays, I always emphasise: 'Your eye safety and lifelong vision are more important than rushing the scan.'

Alternative Imaging Modalities for IOFB Detection

Plain orbital radiographs: Most accessible, effective for detecting metallic fragments >0.5 mm.

Non-contrast CT: Higher sensitivity, detects smaller fragments and defines exact location.

B-scan ocular ultrasound: Useful for posterior segment localisation, but must only be done if globe rupture is excluded.

Documentation and Communication

Documentation protects both patient and staff. Radiographers should record:

- Patient's exact answers to screening questions.
- Which imaging was performed (X-ray/CT).
- Name of radiologist providing clearance.
- If positive, the referral made to ophthalmology.

Clear communication with the patient is equally important. Many patients feel anxious when told about possible 'metal in the eye.' Radiographers should calmly explain the reasons, focusing on safety.

Safety Culture and Training

A 3-year UK review of MRI incidents found that human error in screening was the most common cause of safety events. To reduce risk:

- Departments must have written IOFB pathways.
- Radiographers should undergo regular MRI safety training.
- Simulation of 'what if' scenarios should be part of departmental drills.
- Regular audits should monitor IOFB screening cases and protocol adherence.

Discussion

The UK model demonstrates that with systematic screening, on-the-spot orbital imaging, and ophthalmology referral when required, patient safety can be maintained without compromising workflow too much.

For India, adaptation may be necessary due to differences in healthcare infrastructure. Orbital radiographs should be available in all MRI centres as a minimum safety tool. Radiographers should be empowered to pause MRI when suspicion arises. Strong collaboration between radiographers, radiologists, and ophthalmologists is essential. Patient education is particularly important in industries with high metal exposure.

The principles remain the same: do not proceed with MRI until a metallic IOFB is excluded.

Conclusion

MRI in patients with suspected intraocular foreign bodies is a high-risk scenario. Radiographers, as the first point of safety, must:

- Ask clear ocular screening questions.
- Stop the scan if doubt exists.
- Escalate to radiologists and request orbital imaging.
- Only proceed with MRI after negative imaging or ophthalmology clearance.
- Document and communicate clearly with both patients and clinical teams.

Even though this process may delay diagnosis, it prevents catastrophic outcomes such as lifelong blindness. Patient safety and radiographer responsibility must always take priority.

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Thanks in advance,
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Unveiling the Role of the Subiculum in Scene Perceptual Discrimination Insights from Ultra-High-Field fMRI

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Abstract

Recent advancements in neuroimaging, particularly ultra-high-field functional magnetic resonance imaging (fMRI), have significantly enhanced our understanding of the hippocampus's role in scene perception. This article explores the findings from a study that utilized 7 T fMRI to investigate the subiculum's involvement in scene perceptual discrimination. The study employed a perceptual oddity task, revealing that the subiculum plays a unique role in processing complex scenes, independent of memory performance. This article discusses the implications of these findings for understanding the functional neuroanatomy of the hippocampus and its contributions to cognition, while also providing a comprehensive review of the existing literature on the topic.

Keywords: Hippocampus, Subiculum, Ultra-high-field fMRI, Scene Perception, Perceptual Discrimination, Cognitive Neuroscience

Introduction

Because it provides high-resolution, non-invasive anatomical and functional imaging, magnetic resonance imaging (MRI) has emerged as a key component of contemporary medical diagnosis. However, the sensitivity and specificity needed for early illness diagnosis and accurate molecular-level characterisation of pathological processes are frequently lacking in conventional MRI. This restriction has prompted the creation of targeted contrast agents, especially those based on protein-targeted gadolinium (Gd), which mark a substantial advancement in molecular imaging. These substances are designed to connect to particular proteins that are linked to a number

The hippocampus has long been recognized for its critical role in memory formation and retrieval. However, recent research has expanded our understanding of its functions, particularly in the realm of perceptual processing. The subiculum, a subfield of the hippocampus, has emerged as a key player in scene perception, yet its specific contributions remain poorly understood due to limitations in imaging technology. This article reviews a study that utilized ultra-high-field fMRI to investigate the subiculum's role in scene perceptual discrimination, providing insights into the functional neuroanatomy of the hippocampus.

Background on the Hippocampus

The hippocampus is a complex structure located in the medial temporal lobe of the brain, traditionally associated with memory processes. It is divided into several subfields, including the CA1, CA2, CA3, dentate gyrus, and subiculum. Each of these regions has distinct functions and connectivity patterns, contributing to the overall role of the hippocampus in cognition. The subiculum, in particular, serves as a major output region of the hippocampus, integrating information from various sources and relaying it to other brain areas.

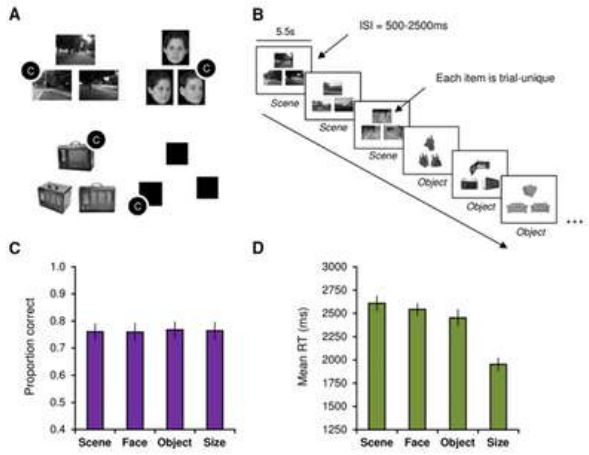

Figure 1. A, Examples of scene, face, object, and size (baseline) oddity trials (C markers indicate correct odd-one-out responses, which were selected using a button box in the scanner). Faces were obtained from the Psychological Image Collection at Stirling (http://pics.stir.ac.uk/); objects were taken from the Hemera Photo-Objects 50,000, Volumes 1–3. B, Schematic illustration of the oddity task. Trials for each category were presented in miniblocks of three trials (shown in the figure for scenes and objects). Trials were presented for 5500 ms with a jittered intertrial interval of 500–2500 ms. C, Accuracy data (proportion correct) for the oddity task. D, RT data for the oddity task. Error bars represent ± SE.

The Role of the Subiculum in Scene Perception

Recent studies have suggested that the subiculum may play a crucial role in higher-order visual perception, particularly in the context of complex scenes. Traditional views of the hippocampus have primarily focused on its involvement in memory, but emerging evidence indicates that it also contributes to perceptual processes. The subiculum's unique position within the hippocampal circuitry suggests that it may be involved in constructing and utilizing internal representations of scenes, which are essential for navigating and interacting with the environment.

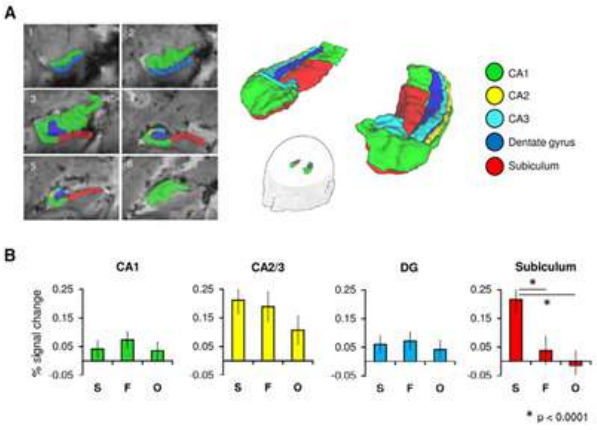

Figure 2. A, Hippocampal subfields (CA1, CA2, CA3, DG, and subiculum) were manually segmented on subjects' ultra-high-resolution T2*-weighted images. Six representative coronal slices of an individual subject's segmentation are shown (left hemisphere; 1, anterior; 6, posterior). Regions CA2 and CA3 were later concatenated as their small size precluded accurate functional localization at our coarser functional resolution of 1.2 mm isotropic. B, Mean percentage signal change plots for correct scene (S), face (F), and object (O) judgements (relative to size baseline) for each hippocampal subfield ROI. Error bars represent ± SE.

Purpose of the Study

The purpose of the study reviewed in this article was to investigate the specific contributions of the subiculum to scene perceptual discrimination using ultra-high-field

fMRI. By employing a perceptual oddity task, the researchers aimed to elucidate the role of the subiculum in processing complex visual information, independent of memory demands. This research is significant as it provides a more nuanced understanding of the functional neuroanatomy of the hippocampus and its contributions to cognition.

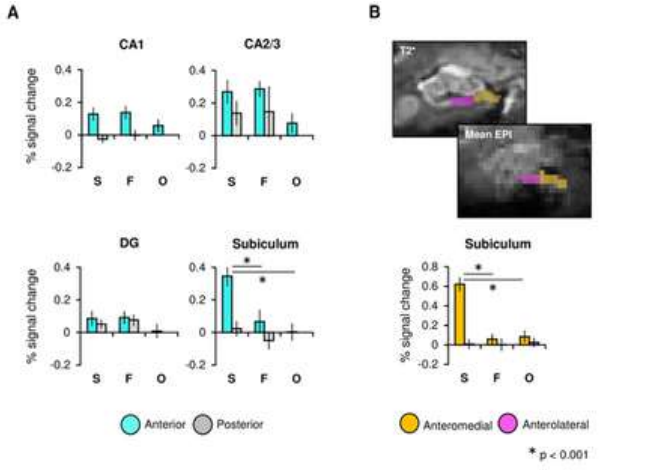

Figure 3. *A*, Percentage signal change plots for anterior and posterior subdivisions within each hippocampal subfield ROI (CA1, CA2/3, DG, and subiculum). *B*, Example ROIs for the anteromedial and anterolateral subiculum shown on both the ultra-high-resolution T2* image and the mean EPI image of a single subject (top). Percentage signal change plot for the medial and lateral subdivisions of the anterior subiculum (bottom). Mean values (across subjects and task runs) are shown for scenes (S), faces (F), and objects (O). Error bars represent ± SE.

The findings from the study revealed several key insights into the role of the subiculum in scene perception:

Preferential Response in the Subiculum

Region-of-interest analyses indicated a significant response in the anteromedial subiculum during scene discrimination tasks, while responses to faces and objects were not observed. This suggests that the subiculum is specifically tuned to process complex scenes [1].

Independence from Memory Performance

Importantly, the subicular response was not influenced by whether the scenes were subsequently remembered or forgotten. This finding supports the notion that the subiculum's role in scene perception is distinct from its involvement in memory processes [2].

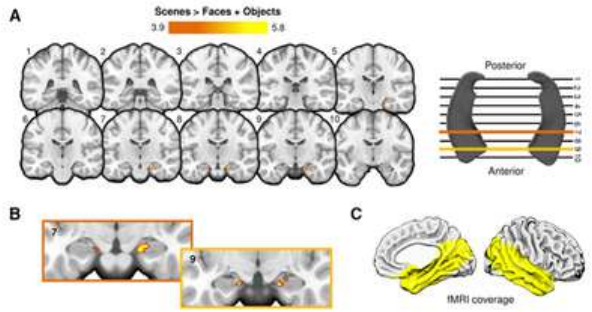

Figure 4. *A*, Significant scene oddity clusters within the hippocampal ROI. Clusters reflecting significantly greater activity for scenes > faces + objects are shown in red-yellow. The statistical map (FWHM, 2 mm) was thresholded at $p = 0.0001$ with a familywise error-corrected cluster threshold of $p < 0.05$. The coronal slices transect the long axis of the hippocampus, as shown in *A* (right). The slice intersecting the most posterior part of the hippocampal formation is depicted in slice 1, and the most anterior slice of the hippocampal body is shown in slice 10. *B*, Magnified images of two slices (7 and 9) showing the location of scene-selective clusters in the anteromedial hippocampus. All activation maps are shown on the MNI152 standard template (1 mm). *C*, Yellow highlighted region depicts the partial field-of-view coverage of our fMRI data.

Minimal Memory Demand

The design of the perceptual oddity task ensured that there was minimal requirement for participants to maintain items in memory, both within and across trials. This further emphasizes that the observed effects in the subiculum reflect perceptual processing rather than mnemonic demands [3].

High-Resolution Imaging

The use of 7 T fMRI allowed for enhanced anatomical resolution, enabling a more refined understanding of the hippocampal

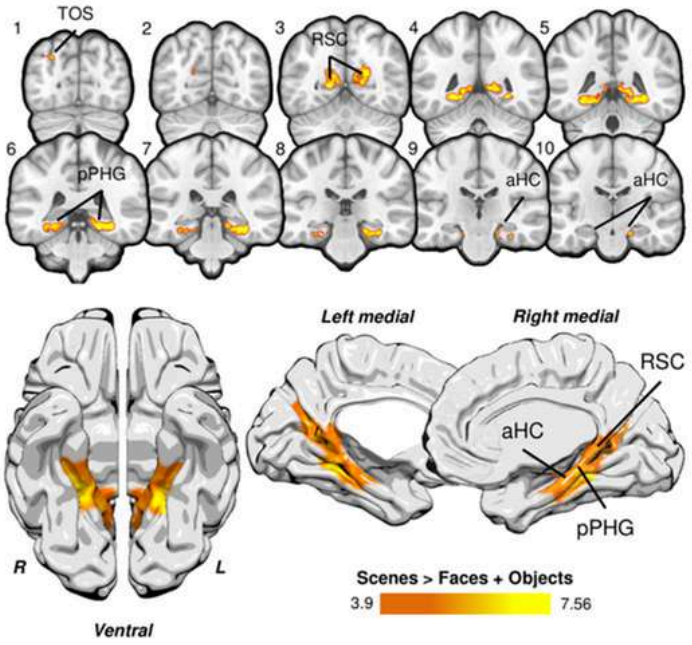

Figure 5. Significant whole field-of-view clusters for scene oddity. Clusters reflecting significantly greater activity for scenes > faces + objects are shown in red-yellow. Significant activity was found bilaterally in anterior hippocampus (aHC), posterior parahippocampal gyrus (pPHG), RSC, and lateral occipital cortex/transverse occipital sulcus (TOS). For visualization, the activation map was projected to the standard MNI152 template (top) and onto the ICBM152 brain template using Surf Ice software (bottom; https://www.nitrc.org/projects/surfice/). The statistical map (FWHM, 2 mm) was thresholded at $p = 0.0001$ with a familywise error-corrected cluster threshold of $p < 0.05$. The field-of-view for our fMRI data is shown in Figure 4C.

subfields' contributions to scene processing. This advancement in imaging technology has provided new insights into the functional neuroanatomy of the hippocampus, particularly the subiculum's unique role in higher-order visual perception [1].

Discussion

Implications for Understanding the Hippocampus

The study's findings underscore the importance of the subiculum in scene perceptual discrimination, highlighting its role as a specialized region for processing complex visual information. By demonstrating that the subiculum's activity is independent of memory performance, the research challenges traditional views of the hippocampus as solely a memory-related structure. Instead, it positions the subiculum as a critical component of the neural circuitry involved in higher-order visual perception.

Theoretical Frameworks

The results of this study align with representational accounts of hippocampal function, which propose that the hippocampus is critical for the formation of complex, conjunctive scene representations. These representations are thought to be utilized in a task-directed manner across both memory and higher-order visual perception [4]. The findings also support the notion that the hippocampus contributes to the construction of internal scene models, which are essential for navigating and interacting with the environment [5].

Future Research Directions

Future research utilizing ultra-high-field fMRI may further elucidate the specific mechanisms by which the subiculum and other hippocampal subfields contribute to perceptual processing and memory. Investigating the interactions between the subiculum and other brain regions involved

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in visual perception, such as the parahippocampal cortex and visual association areas, could provide valuable insights into the neural circuitry underlying scene perception.

Results

The findings from the study revealed several key insights into the role of the subiculum in scene perception:

Preferential Response in the Subiculum: Region-of-interest analyses indicated a significant response in the anteromedial subiculum during scene discrimination tasks, while responses to faces and objects were not observed. This suggests that the subiculum is specifically tuned to process complex scenes [1].

Independence from Memory Performance: Importantly, the subicular response was not influenced by whether the scenes were subsequently remembered or forgotten. This finding supports the notion that the subiculum's role in scene perception is distinct from its involvement in memory processes [1].

Minimal Memory Demand: The design of the perceptual oddity task ensured that there was minimal requirement for participants to maintain items in memory, both within and across trials. This further emphasizes that the observed effects in the subiculum reflect perceptual processing rather than mnemonic demands [2] [3].

High-Resolution Imaging: The use of 7 T fMRI allowed for enhanced anatomical resolution, enabling a more refined understanding of the hippocampal subfields' contributions to scene processing. This advancement in imaging technology has provided new insights into the functional neuroanatomy of the hippocampus, particularly the subiculum's unique role in higher-order visual perception [1].

Conclusion

The study's findings underscore the importance of the subiculum in scene perceptual discrimination, highlighting its role as a specialized region for processing complex visual information. By demonstrating that the subiculum's activity is independent of memory performance, the research challenges traditional views of the hippocampus as solely a memory-related structure. Instead, it positions the subiculum as a critical component of the neural circuitry involved in higher-order visual perception.

These insights have significant implications for our understanding of the hippocampus's functional neuroanatomy and its contributions to cognition. Future research utilizing ultra-high-field fMRI may further elucidate the specific mechanisms by which the subiculum and other hippocampal subfields contribute to perceptual processing and memory. As our understanding of these neural processes deepens, it may pave the way for new interventions in conditions where perceptual and memory functions are impaired.

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आप भी अपना पाठक धर्म निभाएँ

पत्रिका का अंक मिला, डाउन लोड किया, पढा और डिलीट कर दिया. केवल इससे पाठक धर्म नहीं निभ जाता. पत्रिका में प्रकाशित सामग्री से आप सहमत हो सकते हैं या उसमें आप कुछ और जोड़ सकते हैं, तो ऐसे मामलों में अपनी टिप्पणी अथवा प्रतिक्रिया हमें अवश्य लिख भेंजे. इसी प्रकार पत्रिका में जो मुद्दे उठाए गए हों, जो प्रश्न खड़े किए गए हों, उन पर भी खुल कर बहस करें और हमें लिख भेंजे. तात्पर्य यह है कि आप केवल पाठक ही न बने रहें, पाठक धर्म भी साथ में निभाते रहें इससे जहां अन्य पाठक बंधु लाभान्वित होंगे वहीं हमें भी विभिन्न रूपों से मार्गदर्शन मिलेगा. हाँ तो, जब भी समय की मांग हो, कलम उठाना न भूलें.

और एक बात, ये अंक हमने आप तक पहुंचाया, एक प्रबुद्ध रेडियोग्राफर के नाते अब ये आप की ज़िम्मेदारी बनती है कि इस अंक को आप भी और रडीओग्राफेर्स तक पहुंचाए यानि फॉरवर्ड करें.

अग्रिम धन्यवाद.

संपादक

A Review Article on the Advancements in Abdominal MRI

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Abstract
Background: MRI is one of the safest and most advanced diagnostic imaging techniques, but for patients with metallic intraocular foreign bodies (IOFBs), it can present a serious hazard. Ferromagnetic fragments inside the orbit may move or heat under the influence of strong magnetic fields, risking permanent visual loss.

Keywords: Advancement, Abdomen, Motion, Artifacts, Breath hold issues, Parallel Imaging, Simultaneous Multi-Slice Acquisition, Diffusion Imaging, Perfusion Imaging etc

Introduction

A key component of contemporary diagnostic radiology, magnetic resonance imaging (MRI) is distinguished by its remarkable soft-tissue contrast, multiplanar capabilities, and non-ionizing properties. It is especially helpful in assessing the intricate abdominal architecture and in identifying and characterizing diseases of organs such as the kidneys, pancreas, and liver. Conventional abdominal MRI has extensive scan periods and has previously been limited by motion artifacts from respiration, intestinal peristalsis, and patient movement, despite its many benefits. These difficulties may limit the examination's diagnostic potential, require more scans, and degrade image quality.

In recent years, there has been a significant shift in abdominal MRI technology, fuelled by advancements in hardware, pulse sequences, and image reconstruction methods. In recent years, there has been a significant shift in abdominal MRI technology, fuelled by advancements in hardware, pulse sequences, and image reconstruction methods. This new wave of MRI techniques is specifically aimed at addressing these persistent challenges, resulting in quicker, more reliable, and informative scans. This review article examines the groundbreaking progress in abdominal MRI, emphasizing crucial technological advancements that have greatly improved diagnostic capabilities and broadened clinical uses. We will explore how these innovations—from speedier imaging methods to sophisticated functional sequences—are transforming the field and enhancing patient care.

We Need the Speed (Overcoming Motion Artifact)

Motion artifacts are a significant challenge in abdominal MRI, primarily caused by involuntary movements like breathing and bowel peristalsis. To overcome these, modern MRI scanners employ various strategies that prioritize speed and motion-compensation.

Motion Compensation and Correction

These techniques don't necessarily make the scan faster but are designed to handle and correct for motion during the acquisition itself.

Respiratory Gating and Triggering:

This technique monitors the patient's breathing using a bellows or navigator echoes and collects data only during a specific, consistent phase of the respiratory cycle (such as end-expiration). This approach ensures that all data is gathered from the same position, minimizing motion-related ghosting. Although this may prolong the overall scan duration, it greatly enhances image quality in challenging imaging regions.

Golden-angle Radial Sampling:

This method gathers data in a continuous and non-linear manner. The distinctive radial path guarantees that, despite constant movement, k-space is filled in a manner that supports motion-resistant image reconstruction.

The PROPELLER/BLADE

It is very helpful for patients who are not cooperative. Sampling approach uses rotating strips or "blades" to collect data in k-space. The images are easier to comprehend since the motion is spread across several blades, creating artifacts that resemble a general blurring rather than discrete ghosts.

Deep Learning (DL) Reconstruction

It is a new and effective method. High-quality images can be recovered from extremely little, under sampled, or motion-corrupted data using AI models trained on enormous MRI scan datasets. DL is an effective approach for motion artifact reduction since it may drastically cut scan times without sacrificing image quality.

Fast Images (Faster Imaging Techniques)

Accelerated imaging techniques in MRI are methods designed to significantly reduce scan time. Intentionally gathering less data than is customarily needed and employing sophisticated algorithms to create a high-quality image from that scant data are how this is accomplished

a)Parallel Imaging

This fundamental technique speeds up data collecting by utilizing the spatial sensitivity of many receive coils. "under samples" kspace, or the raw data space of an MRI scan, rather than gathering all the information required for a complete image. every coil has a different perspective on the anatomy, the under sampled data from all of the coils combined contains sufficient information to rebuild an image devoid of artifacts. Using pre calculated coil sensitivity maps,

SENSE (Sensitivity Encoding) reconstructs the image by "unfolding" aliased (or folded) signals.
Generalized Auto calibrating Partially Parallel Acquisitions, or GRAPPA, uses a tiny, centrally acquired calibration area to immediately fill in the missing k-space data

b) CS or Compressed Sensing

- In contrast to other under sampling techniques, CS gathers data in a random, nonuniform fashion, avoiding the structured artifacts.
- The most believable, sparse image that matches the collected data is then found using a sophisticated iterative reconstruction process.
- Very high acceleration factors are made possible by this, frequently allowing free breathing scans that would otherwise necessitate lengthy breath-holds

c) Simultaneous Multi-Slice (SMS) Acquisition

- Simultaneous Multislice (SMS) acquisition significantly cuts down on scan duration. Because it uses a single multiband radiofrequency (RF) pulse to excite many slices simultaneously—which are typically excited sequentially—it is frequently referred to as Multiband (MB) imaging.

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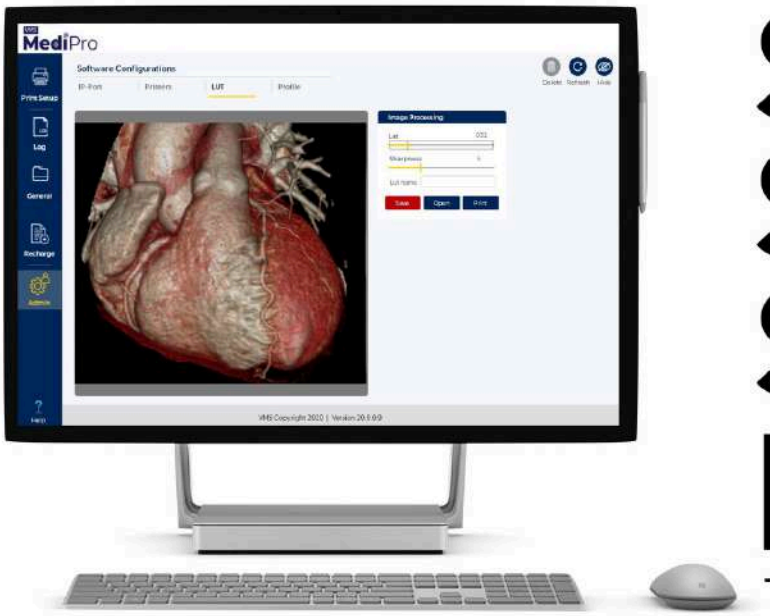

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- The primary benefit of SMS is a dramatic reduction in scan time. By shortening the acquisition window, SMS is highly effective at minimizing motion artifacts, especially in fast-moving areas like the abdomen and heart. It can even make some free-breathing sequences feasible.
- The time savings can be used to acquire more slices, increase the spatial resolution of each slice, or improve the temporal resolution for dynamic imaging

Detailed Images (Functional & Multi-Parametric Imaging)

Beyond conventional anatomical imaging, functional and multiparametric MRI approaches offer quantitative insights into tissue health. There is substantial evidence to support their clinical usage, and they are essential for describing disease in abdominal organs such as the liver and pancreas. [3]

a) Diffusion- Weighted Imaging

DWI measures the microscopic movement (diffusion) of water molecules within tissues. The signal is highly sensitive to the presence of cell membranes and macromolecules that restrict this movement.

Evidence: Because excessive cellularity (such as tumour's) restricts movement, water diffusion is measured by DWI. This results in brilliant images on DWI and low values on quantitative Apparent Diffusion Coefficient (ADC) maps. Research has demonstrated that demonstrated that DWI has a high perceptivity and particularity for relating and classifying nasty abdominal lesions. also, it's used to track how well a treatment is working; a rise in ADC values after remedy signifies cell death.

b) Glamorous Resonance Elastography (MRE)

MRE is non-invasive fashion that measures towel stiffness, which is a crucial biomarker for fibrosis and other pathologies substantiation substantiation MRE is a veritably precise way to measure towel stiffness. It's allowed to be the most accurate non-invasive system for carrying liver fibrosis, surpassing indeed ultrasound elastography and serum testing. Because of its quantitative nature and high reproducibility, it's a vital tool for tracking the course of a complaint and assessing the effectiveness of treatment.

c) Dynamic Differ- Enhanced (DCE)

MRI This fashion is the most common for perfusion imaging and is frequently bandied under the marquee of" functional imaging." It involves edging in a gadolinium- grounded discrepancy agent and fleetly acquiring a series of images as the discrepancy passes through the Akins. substantiation DCE- MRI provides information on blood inflow and vascular permeability by analysing the passage of a discrepancy agent through Akins. In oncology, this is especially helpful for describing tumour's according to their distinct vascular patterns. Clinical data supports the use of DCE-MRI to track response to anti-angiogenic drugs, as perfusion differences can serve as an early predictor of treatment efficacity, constantly before a tumour's size changes.

d) MR Spectroscopy (MRS)

MRS is a Non-invasive fashion that provides a" metabolic point" of a towel by measuring the attention of different metabolites. substantiation the metabolic "point" of towel is handed by MRS. In order to diagnose and treat Non-Alcoholic Adipose Liver Disease (NAFLD), it's the gold standard non-invasive fashion for measuring liver fat content. Compared to liver vivisection, MRS offers a direct dimension of fat that has been demonstrated to be veritably accurate and unremarkable.

Application (Clinical operation)

Lesion Characterization MRI's capability to give multiparametric and functional information enhances its capacity for lesion discovery and characterization, particularly in solid organs like the liver, order, and pancreas. Bowel and Biliary Imaging New ways are expanding the operation of MRI to the evaluation of the pancreatic and biliary ductal systems, as well as the bowel itself

a) Prolixity- Weighted Imaging (DWI)

Operations - Characterization and discovery of excrescences Distinguishing benign from nasty lesions in the feathers, liver, and pancreas.

Remedy monitoring Following treatment, an increase in the ADC value may signify cell death and a successful remedial outgrowth.

Liver fibrosis One promising system for assessing inflammation and fibrosis.

b) Dynamic Differ- Enhanced (DCE) MRI

Operations - Excrescence characterization Assisting in the isolation of colourful excrescence forms according to their distinct vascular patterns.

Monitoring anti-angiogenic curatives Assessing an excrescence's response to treatments that target its blood force is known as covering anti-angiogenic drugs.

c) Glamorous Resonance Elastography (MRE)

Operations - Liver fibrosis staging Compared to other non-invasive ways similar as blood testing and ultrasound- grounded elastography, MRE is allowed to be the most accurate way to identify and carry liver fibrosis.

Assessing other organs Research is ongoing into the operation of MRE to estimate renal, pancreatic, and splenic stiffness is still being studied.

d) MR Spectroscopy (MRS)

Operations-

Liver fat quantification the gold standard for quantitative, non-invasive liver fat dimension is MRS, which is essential for both diagnosing and tracking non-alcoholic adipose liver complaint (NAFLD).).

Excrescence characterization Because nasty excrescences have advanced cell membrane development, they constantly have an enhanced choline peak. nasty excrescences frequently show an elevated choline peak due to increased cell membrane development

Conclusion

Individual imaging will be revolutionized by advanced abdominal MRI ways similar as glamorous Resonance Spectroscopy (MRS), Perfusion MRI, Diffusion- Weighted Imaging (DWI), and glamorous Resonance Elastography (MRE). These ways give a deeper sapience of cellular and metabolic changes within organs, going beyond conventional anatomical perspectives. They grease earlier illness identification and more accurate opinion by offering preliminarily unheard- of detail on towel function, stiffness, blood inflow, and chemical composition. unborn non-invasive diagnostics will probably calculate heavily on these slice-edge styles since their combination with artificial intelligence and machine literacy has the implicit to greatly enhance health issues and customize patient care.

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3D Mammography (Tomosynthesis): A New Era in Breast Cancer Screening

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Abstract

Breast cancer remains one of the leading causes of cancer-related deaths among women worldwide. Early detection through effective screening methods is crucial for improving survival rates. Traditional 2D mammography has been the standard screening tool for decades; however, advancements in technology have led to the development of 3D mammography, or digital breast tomosynthesis (DBT). This article explores the impact of 3D mammography on breast cancer screening, focusing on its enhanced detection rates, reduced need for follow-up imaging, improved accuracy for women with dense breast tissue, and the overall patient experience. By synthesizing findings from various studies and patient experiences, this article aims to provide a comprehensive understanding of how 3D mammography is transforming breast cancer screening and its implications for women's health.

Introduction

Breast cancer is a significant public health concern, with millions of women diagnosed each year. The importance of early detection cannot be overstated, as it plays a critical role in improving treatment outcomes and survival rates. Traditional 2D mammography has been the cornerstone of breast cancer screening, but it has limitations, particularly in women with dense breast tissue. The introduction of 3D mammography has revolutionized the screening process, offering numerous advantages that enhance detection rates and improve the overall patient experience.

Enhanced Detection Rates

One of the most significant benefits of 3D mammography is its ability to increase the detection of invasive breast cancers. Research has shown that 3D mammography improves the detection rate of breast cancer by 41% compared to 2D mammography alone. This increase in detection rates is primarily due to the technology's capability to see through overlapping breast tissues, which significantly reduces the number of false positives [1].

The enhanced clarity provided by 3D mammography allows radiologists to identify tumors that may be obscured in traditional 2D images. This is particularly important for women with dense breast tissue, where the risk of missed cancers is higher. By providing a more accurate assessment of breast health, 3D mammography contributes to earlier diagnosis and treatment, ultimately improving patient outcomes.

Reduced Need for Follow-Up Imaging

Another critical advantage of 3D mammography is its ability to minimize the number of callbacks for additional imaging. Women often experience anxiety and stress when they receive a callback after a 2D mammogram, which can happen due to unclear or ambiguous results. The advanced technology of 3D mammography reduces the rate of false alarms, leading to a more reassuring experience for patients [2].

The reduction in follow-up imaging not only alleviates patient anxiety but also decreases healthcare costs associated with unnecessary additional tests. This efficiency in the screening process is particularly beneficial for women who may be apprehensive about undergoing mammograms. By providing clearer images and reducing the likelihood of callbacks, 3D mammography enhances the overall patient experience.

Fig 1.1 3D Mammogram or Tomosynthesis

Improved Accuracy for All Women

3D mammography is designed to benefit women of all shapes, sizes, and breast densities. Dense breast tissue can obscure tumors on standard 2D scans, making it challenging to detect potential malignancies. However, with the use of tomosynthesis, the multidimensional perspective allows radiologists to better differentiate between benign and potentially malignant areas in dense breasts [3].

This improved accuracy is crucial for women with dense breast tissue, who may otherwise face a higher risk of undetected cancers. The technology's ability to provide clearer images and more detailed information empowers radiologists to make more informed decisions regarding patient care. As a result, women can have greater confidence in their screening results and the subsequent steps in their healthcare journey.

The Patient Experience: A Human Perspective

The experience of undergoing a mammogram can be anxiety-inducing for many women. For instance, consider a woman named Sarah, who has just received her annual mammogram appointment. As someone with dense breast tissue, she is familiar with the anxiety that accompanies this necessary screening. However, with the option of 3D mammography, Sarah steps into the imaging room, where she is greeted by a friendly technician [4].

The procedure for 3D mammography is similar to that of a conventional mammogram, but patients can expect clearer images. As Sarah feels the machine gently compress her breast, she knows that this discomfort is temporary and worth it for her peace of mind. The reassurance provided by the advanced technology helps to alleviate some of the stress associated with the screening process. Moreover, the positive patient experience extends beyond the procedure itself. The reduction in callbacks and false positives contributes to a more supportive environment for women undergoing breast cancer screening. By minimizing anxiety and providing clearer results, 3D mammography fosters a sense of trust between patients and healthcare providers.

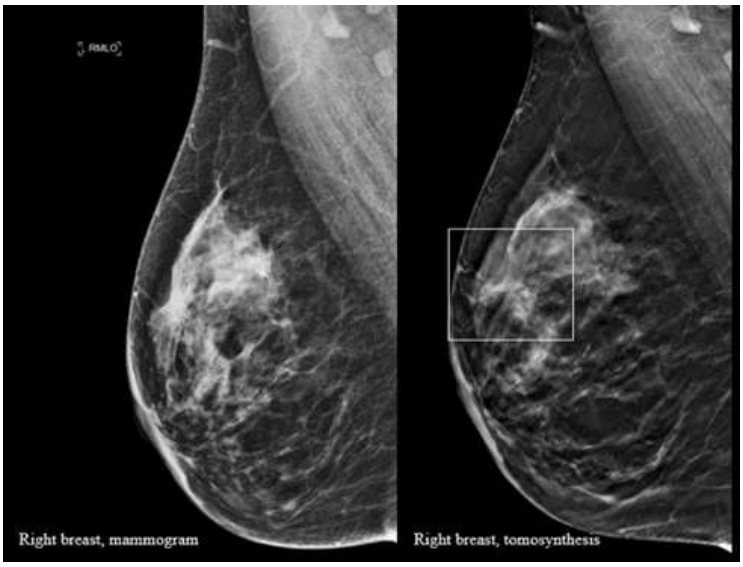

Fig 1.2 breast cancers detected with 3D mammography

What is 3D Mammography?

3D mammography, or tomosynthesis, is an advanced imaging technique that creates a three-dimensional picture of the breast. Unlike traditional 2D mammography, which takes flat images from two angles, DBT captures multiple images of the breast from various angles, reconstructing them into a comprehensive 3D representation. This process allows for better visualization of breast tissues, making it easier for radiologists to spot potential abnormalities. This technology has been widely adopted in many imaging centers, leading to a more in-depth understanding of breast tissue and improving the chances of detecting cancers at an early stage

Technological Advancements in 3D Mammography

3D mammography captures multiple images of the breast from various angles, reconstructing them into a comprehensive 3D representation. This process allows for better visualization of breast tissues, making it easier for radiologists to spot potential abnormalities. The technology has been widely adopted in imaging centers, leading to a more in-depth understanding of breast tissue and improved chances of early cancer detection [3]. The advancements in imaging technology have also led to ongoing research and development in the field of breast cancer screening. As more studies are conducted, the benefits of 3D mammography continue to be validated, reinforcing its role as a critical tool in the fight against breast cancer.

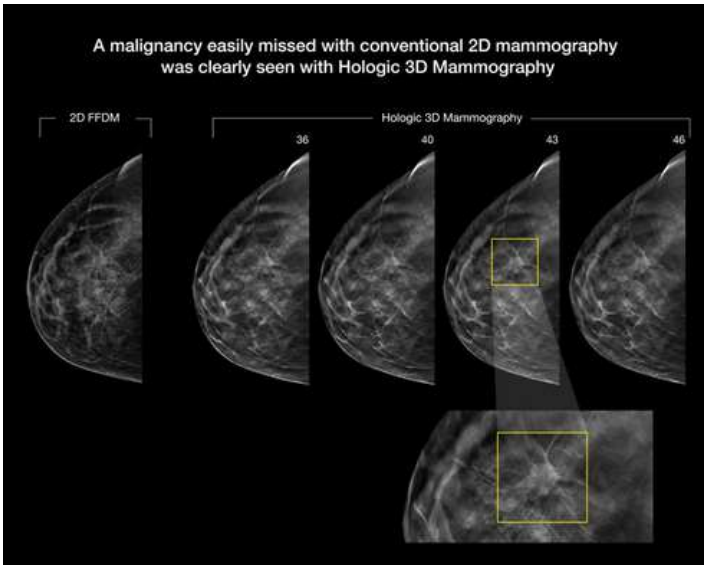

Fig 1.3 Digital breast tomosynthesis (DBT)

Why Choose 3D Mammography?

Enhanced Detection Rates

Research shows that 3D mammography increases the detection of invasive breast cancers compared to traditional methods. A study published in the "Journal of the American Medical Association" found that 3D mammography improved the detection rate of breast cancer by 41% compared to 2D mammography alone (Yaffe, M. J., et al., 2012). This technology allows radiologists to see through overlapping breast tissues, significantly reducing the number of false positives.

Reduced Need for Follow-Up Imaging

One of the most significant advantages of 3D mammography is its ability to minimize the number of callbacks for additional imaging. Women often experience anxiety and stress when called back for further tests, which can happen due to unclear or ambiguous results from 2D mammograms. With 3D

Conclusion

In conclusion, 3D mammography represents a significant advancement in breast cancer screening, offering improved detection rates, reduced anxiety for patients, and enhanced accuracy for women with dense breast tissue. The technology's ability to provide clearer images and minimize callbacks has transformed the patient experience, making mammograms less daunting and more effective. As 3D mammography continues to gain traction in clinical practice, it holds the promise of better outcomes in breast cancer detection and treatment.

The ongoing research and development in this field will likely lead to further improvements in screening methods, ultimately benefiting women's health and contributing to the fight against breast cancer. As healthcare providers and patients embrace these advancements, the future of breast cancer screening looks brighter, with the potential for earlier detection and improved survival rates.

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Role of MRI in Detecting Rabies and Viral Encephalitis: A Mini Review

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Abstract
Rabies is one of the most fatal viral infections of the central nervous system, almost always leading to death once symptoms develop. However, rare instances of survival and atypical presentations have broadened the understanding of its neuropathology. Magnetic resonance imaging provides critical insights into the detection and progression of rabies encephalitis, aiding in differentiation from other viral encephalitis. This review synthesizes evidence from clinical imaging studies and case reports that describe MRI features of rabies alongside comparative findings in other viral central nervous system infections. MRI has revealed characteristic involvement of the subcortical white matter, basal ganglia, thalami, brainstem, and spinal cord in rabies, although patterns overlap with other neurotropic viruses. Structured imaging approaches and serial imaging play vital roles in monitoring disease evolution and identifying atypical forms. The review underscores MRI's value in clinical diagnosis, highlights limitations, and outlines future directions for integrating imaging with laboratory diagnostics to improve management of viral encephalitis.

Keywords
Rabies; Viral encephalitis; Magnetic resonance imaging (MRI); Neuroimaging; Central nervous system; Viral infections; Milwaukee protocol

Introduction

Rabies is a devastating acute viral infection; nearly uniformly fatal once clinical symptoms appear. Globally, tens of thousands of human deaths occur annually, with India alone accounting for a significant proportion (Karande et al., 2015). Traditionally, diagnosis of rabies has relied on clinical features such as hydrophobia, aerophobia, fluctuating consciousness, and autonomic dysfunction, along with confirmatory laboratory testing. However, Magnetic resonance imaging has emerged as a valuable adjunct, especially in atypical or paralytic forms where classical features may be absent.

Historically, rabies survival was virtually unheard of. In 2004, the Milwaukee protocol was introduced following the survival of a 15-year-old girl, offering new hope albeit with limited success (Lu et al., 2015). MRI in such rare survivors has provided unique opportunities to study the temporal evolution of rabies encephalitis, contributing to an improved understanding of its neuropathological progression.

Beyond rabies, MRI has been extensively applied to other viral encephalitis such as Japanese encephalitis, enteroviral infections, and herpes simplex encephalitis. Viral CNS infections often demonstrate specific topographic involvement, including temporal lobe predilection in herpes simplex encephalitis and thalamic involvement in Japanese encephalitis (Rumboldt, 2008; Handique, 2011; Ramli & Bae, 2023). Understanding these patterns is critical for accurate diagnosis and management.

This review synthesizes evidence from five selected studies and reviews to explore how rabies is detected and monitored using MRI, how rabies imaging compares to other viral CNS infections, and what future directions can enhance imaging-based diagnosis.

Methods: MRI Detection of Rabies

MRI findings in rabies have been primarily documented in case-based literature. Lu et al. (2015) reported the sequential MRI findings in an eight-year-old girl who survived paralytic rabies after receiving the Milwaukee protocol. Initial MRI demonstrated T2 FLAIR hyperintensities in subcortical white matter, with enhancement in the cauda equina nerve roots. Subsequent imaging revealed progression of abnormalities to bilateral cerebral hemispheres and dorsal root ganglia, followed by partial resolution in line with clinical recovery.

Similarly, Karande et al. (2015) described MRI features in a six-year-old boy with atypical rabies encephalitis. His MRI showed hyperintensities in the basal ganglia, thalami, cerebellum, and diffuse periventricular white matter involvement. The imaging findings initially mimicked acute disseminated encephalomyelitis (ADEM), but the diagnosis was later confirmed by serological testing and rising rabies virus neutralizing antibody titers.

Comparative literature reinforces that rabies imaging overlaps with other viral CNS infections. For example:
·Enteroviruses may involve the medulla, pons, midbrain, cerebellar dentate nuclei, and spinal cord anterior horns, producing symmetric bilateral lesions on MRI (Rumboldt, 2008).

·Japanese encephalitis is characterized by bilateral thalamic involvement, frequently asymmetric, with substantia nigra and basal ganglia also affected (Handique, 2011; Ramli & Bae, 2023).

Herpes simplex encephalitis typically affects the temporal lobes, producing unilateral or bilateral asymmetric cortical and subcortical lesions (Ramli & Bae, 2023).

Thus, while rabies MRI findings are not pathognomonic, their pattern of brainstem, basal ganglia, and spinal nerve root involvement supports diagnostic suspicion, particularly when correlated with clinical history of animal exposure.

Results

Case Evidence in Rabies

1. Survival under Milwaukee Protocol (Lu et al., 2015):

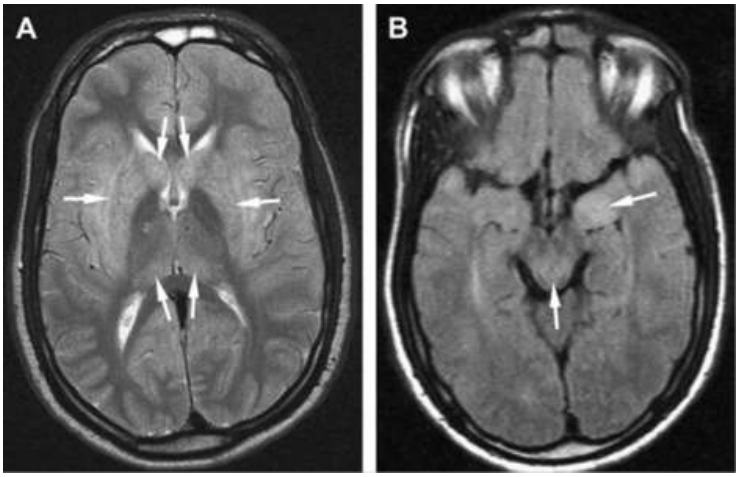
- Early MRI showed focal T2 hyperintensities and cauda equina nerve root enhancement.
- Disease progression revealed widespread cerebral hemispheric abnormalities.
- Later MRI showed resolution of dorsal cauda equina and muscle enhancement, consistent with clinical improvement.
- This sequential imaging highlighted the dynamic evolution of rabies in both brain and spine.

2. Atypical Rabies Encephalitis (Karande et al., 2015):

- MRI mimicked ADEM with hyperintensities in basal ganglia, thalami, cerebellum, and periventricular white matter.
- Diagnosis was confirmed by serology and CSF antibody titers.
- The case emphasized how atypical rabies may masquerade as other encephalitides, underscoring the importance of correlating MRI with laboratory evidence.

Comparative Viral Encephalitis Findings

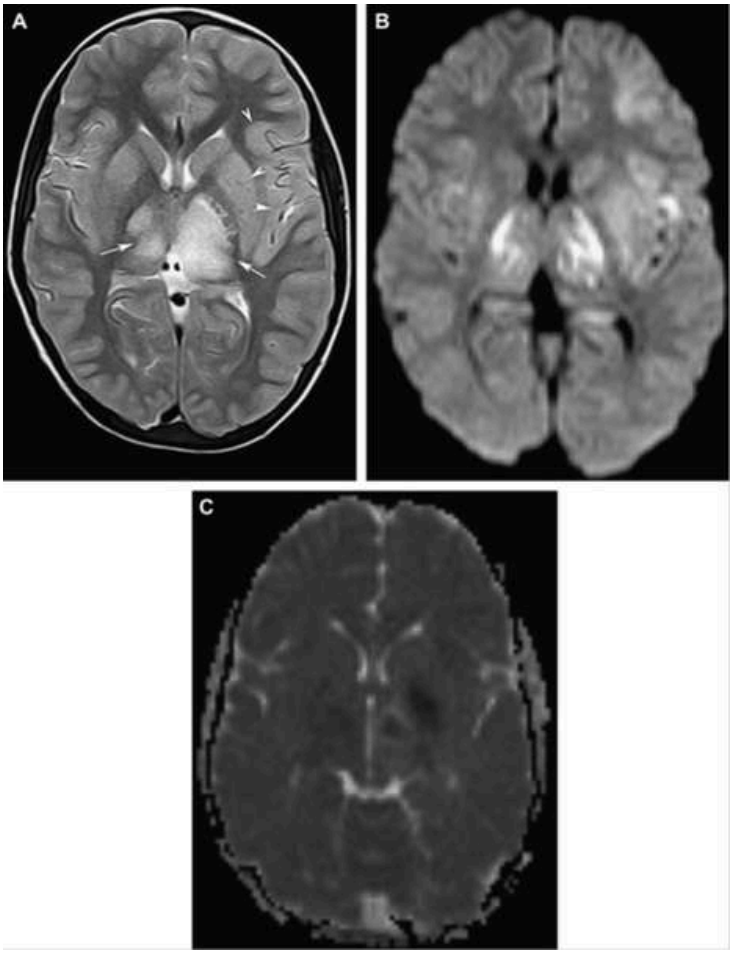
·Enteroviruses: Symmetric brainstem and anterior horn lesions of the spinal cord are considered characteristic MRI findings (Rumboldt, 2008).



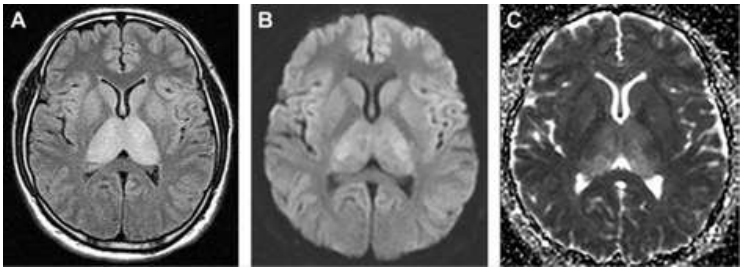
A 51-year-old man with encephalitic rabies. (A) Axial T2-weighted image at the level of basal ganglia shows hyperintensity and mild mass effect involving bilateral caudate head, lentiform nuclei, and thalami (arrows). (B) Axial FLAIR image at an inferior level shows hyperintensity in the dorsal midbrain and left uncus and hippocampus (arrows).

Japanese encephalitis: MRI lesions typically localize to the thalami, basal ganglia, substantia nigra, and hippocampi. Lesions appear hyperintense on T2 and FLAIR sequences and often bilateral but asymmetric (Handique, 2011).

Structured approaches: Ramli & Bae (2023) propose MRI-based anatomical localization strategies to guide differential diagnosis, highlighting rabies and enteroviruses for brainstem involvement, and Japanese encephalitis for bilateral thalamic lesions.



An 8-year-old boy with JE presented with fever for 5 days and altered sensorium for 2 days. MR imaging was done on day 6 of onset of illness. (A) T2-weighted MR imaging shows bilateral asymmetric thalamic lesions (arrows) with focal brain swelling. Note subtle lesions in the left putamen and insula (arrowheads). (B) Diffusion weighted image and (C) apparent diffusion coefficient (ADC) map show restricted diffusion in the left basal ganglia and thalami. Subtle hyperintensities are also noted in the left insula and frontal cortex in (B).



Japanese encephalitis (A) FLAIR image shows bilateral symmetric high signal lesions in the thalamus. (B, C) Most of the lesions show high signal on DWI and mixed ADC values.

Collectively, these findings confirm MRI's capacity to not only identify rabies-related abnormalities but also distinguish rabies from other viral encephalitides based on lesion distribution and temporal evolution.

Future Directions

Non-specificity: Many viral encephalitis share overlapping MRI features, making definitive diagnosis difficult without laboratory correlation (Handique, 2011; Ramli & Bae, 2023).

Need for structured imaging frameworks: Ramli & Bae (2023) emphasize a structured diagnostic approach based

on anatomical localization (temporal lobes, thalami, brainstem, corpus callosum) to improve accuracy.

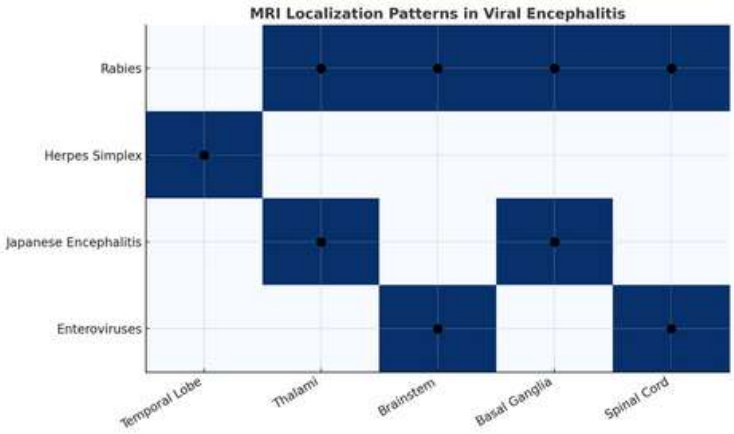
Serial imaging in survivors: Case reports demonstrate the value of repeat MRI for tracking disease progression and recovery (Lu et al., 2015). More systematic studies could establish prognostic indicators.

Integration with laboratory diagnostics: MRI should be integrated with antibody titers, PCR, and serology to strengthen diagnostic confidence (Karande et al., 2015).

Global health implications: Given the high rabies burden in Asia, combining imaging with vaccination, post-exposure prophylaxis, and public health measures remains essential to reduce mortality (Karande et al., 2015; Handique, 2011).

Conclusion

MRI has proven to be an invaluable tool in the study and diagnosis of rabies encephalitis. Although rabies is almost always fatal, rare survivor and atypical cases demonstrate that MRI can reveal the dynamic evolution of CNS lesions, particularly in subcortical white matter, basal ganglia, thalami, brainstem, and spinal nerve roots. Comparative evidence with other viral encephalitis highlights characteristic lesion topographies that assist in differential diagnosis.



This visualization highlights lesion topographies described in your five references (Lu et al., 2015; Karande et al., 2015; Rumboldt, 2008; Handique, 2011; Ramli & Bae, 2023).

While MRI alone cannot provide a definitive diagnosis of rabies, when integrated with serology and clinical history, it significantly enhances diagnostic confidence. The future lies in structured imaging frameworks, systematic use of serial MRI, and integration with laboratory diagnostics to improve outcomes in viral encephalitis.

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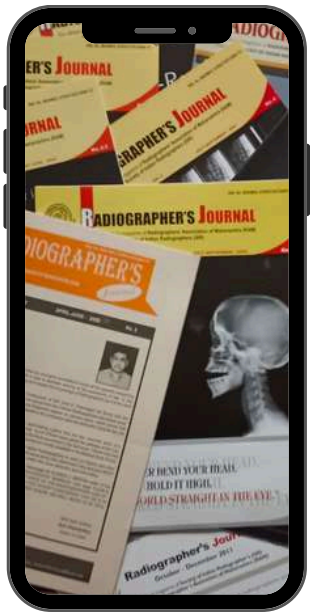

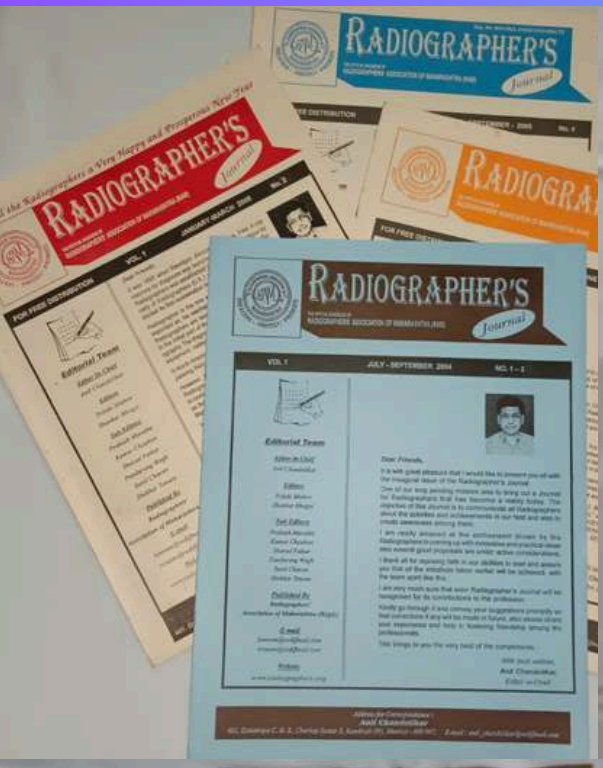

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