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A.L.A.R.A
Informative Pages

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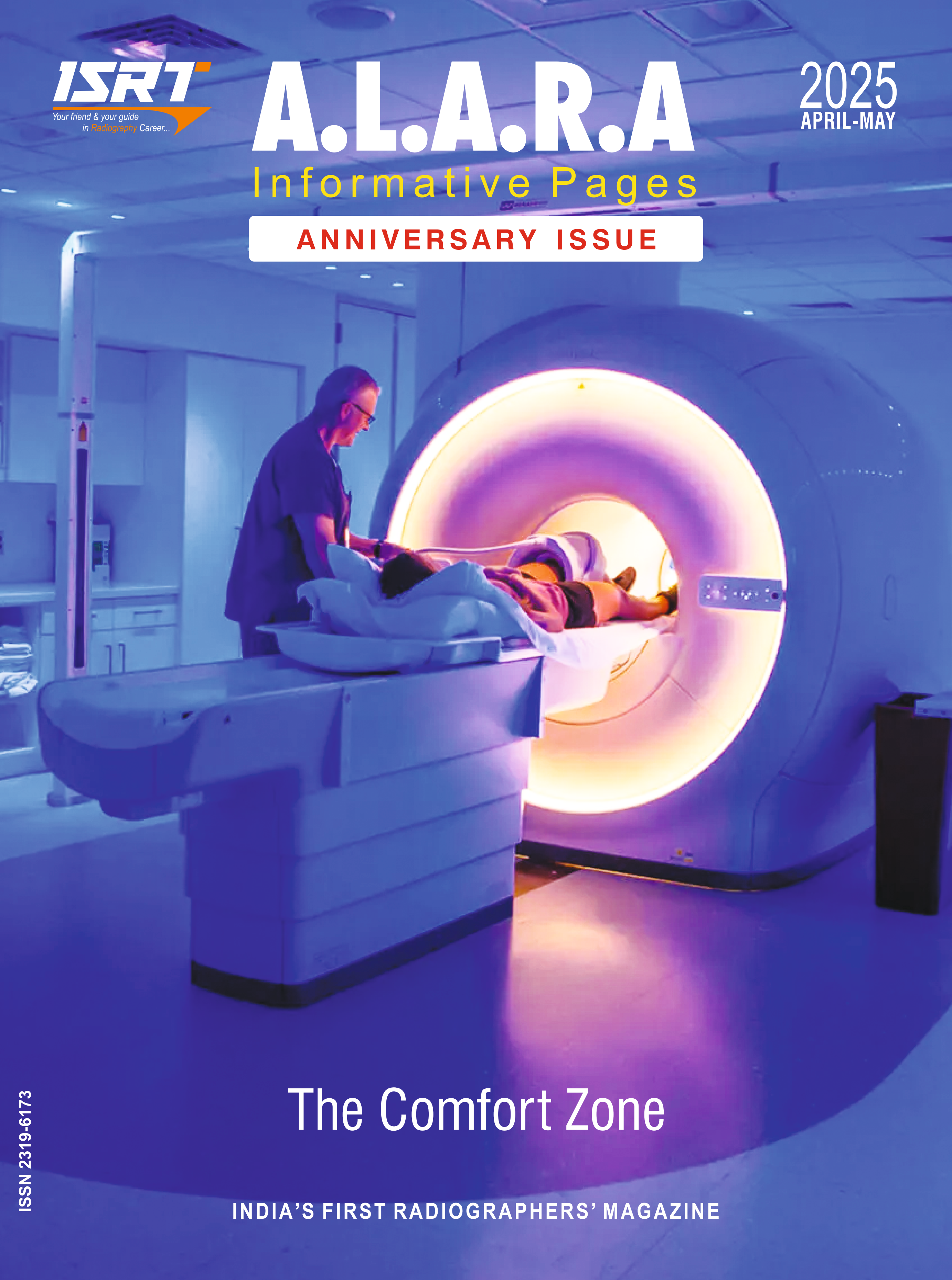
ANNIVERSARY ISSUE

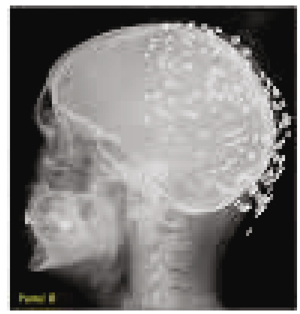


The Comfort Zone

INDIA'S FIRST RADIOGRAPHERS' MAGAZINE

ISSN 2319-6173

Think out of the box !



Hair extensions with ferromagnetic beads may cause unpleasant experience during MRI scan like that happened to Savannah McAllister. She revealed the incident through a social media video, the bad experience she had while undergoing MRI. She blames the technologist for the whole happening, now spiralled a debate in MR imaging and safety issues. Savannah says that she had not been asked for any hair extensions before procedure. While inside the MR room she felt like her hair pulled up, the same she informed to the technician but didn't care much but advised her to put up her hair. Though she had a painful scan the scan went well, but left behind a new concern for safety. Hair extensions with metal beads, similar cosmetic additions have to be bear in minds, new checks and concerns for technologists, but still in some places mishaps are happening. MR safety needs to be redefined.

ISRT

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28 Anniversary

Alara, India's first Radiographers' magazine is stepping into the 28th anniversary. Started off from the land of sweet meat by a group of youthful technologists with sky high ambitions and new way of thinking rolled out the first issue twenty-seven years back. Originally designed only to be circulated inside Kerala later reached all across the nation and even international destinations through Indian Society of Radiographers' and Technologists, the adoption reiterates the ISRT's commitment to elevate the professional standard of technologist fraternity in India.

ALARA is undoubtedly a shot in the arm of the elite national professional organization which is a member society of International Society of Radiographers and Radiological Technologists. Alara is serving as an ample platform to share knowledge, information and other relevant matters evolving out of radiology and allied sciences. The young brains have their thinkings on the subject printed out and circulated into the community they belong, indeed a big opportunity to grow further. Knitting the fragments of knowledge, news, information and latest happenings Alara is keeping its momentum in a gentle paced manner reaching out to its well-wishers, supporters and contributors regularly. Hiccups are still there in respect of not reaching at some destinations, not due to direct fault from the managerial side but some sort of technical and regional issues with postal services have been identified, hopefully will be sorted out in near future.

Its time for you to indulge yourself in to this special annual edition of ALARA, brush up your mind with new and old as the contents reveals.

Editor in Charge

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Most exceptional Woman of all time

Suraj Sugunan
Editor in Charge, ALARA

For ALL Women and Girls: Rights. Equality. Empowerment. ", the theme under which the International Women's Day On 8 March 2025 was celebrated in most part of the world, seems most needy and timely but a little awkward in the sense that gender equations are still not levelled even in this modern era, where Sunita Williams has secured the second longest stay of a total over 608 days in space during her multiple space endeavours. The theme sentence gently says to the world, the women need more rights, more equality and more empowerment, they are still cornered in many societies and in many parts of the world.

On the other hand, there are healthy societies with zero gender discrimination, where women rub their shoulders with their muscular counterparts in tandem with more synergy and energy keeping their heads levelled in every sphere of activity. The coherence of genders is the most anticipated thought, shall be propagated into every society, every village and in every human existence, a long way to go, indeed a better world is possible where men and women share equal respect and equal status, the barriers are many, the obstacles are laid, the minds are hypnotized by the chauvinist thoughts through customs, practices rituals etc. which are still a formidable force that needs to be crushed to gain the noble aim of gender neutral world.

Citing here is something about the most exceptional woman, particularly the scientific world has ever seen, Maria Salomea Sklodowska-Curie, "Madame Curie" the mother of modern science, the first person ever to receive two-time Nobel prizes in two different streams that too in the 19th century where the males prevailed all the world over. The 1927 Solvay Conference photograph underscores Marie Curie's scientific status along with the giants including, Albert Einstein, Werner Heisenberg, and Max Planck. Marie Curie was the one and only woman in that high intellect photograph of a group of twenty-nine esteemed scientists who gathered at Solvay Conference in Brussels in 1927 to discuss quantum theory, seventeen out of them later grabbed the prestigious Nobel recognition, the photograph depicts such a cream of master brains available at that time all the world over, the striking factor is the female presence, the intellect established gender equality at its excellence, mind the time it was nineteenth century.

Madame Curie" was born 7 November 1867 in Warsaw, Poland, lost her mother early then moved to Paris in 1891 where her elder sister was pursuing higher studies. Later Marie joined Sorbonne University in Paris where she gained knowledge in physics and mathematics. During her days in Paris the scientist Pierre Curie stole her heart and both got married one year later, soon Maria adopted the French spelling to her name as Marie. Then the couple became research workers at the School of Chemistry and Physics in Paris where they conducted many experiments fascinated by the works of Professor Henri Becquerel on invisible rays given off by Uranium. In 1903 Marie and Pierre were awarded the Nobel Prize for Physics jointly with Henri Becquerel. Marie lost her better half in the year 1906 in the form of an accident. Marie held her nerve, pursued association with her research on pitchblende that resulted in the discovery of Polonium a highly radioactive element more than three hundred times than that of Uranium.

Still not satisfied with her works on pitchblende Marie continued to explore more that lead her to the assumption that there may be another radioactive element other than Polonium in pitchblende which could be in smaller quantities but with higher radioactivity. In 1911 Nobel prize in Chemistry was awarded to Marie Curie for her discovery and extraction of Radium. Her long association with highly radioactive elements left her ill and unhealthy at times but she kept them aside and continued her quest for knowledge with unwavering spirit.

In the year 1914 Marie Curie established Radium institute in Paris. But in the same year World War 1 broke out she could not pursue much on her new institute but she shifted her attention to the thought of making portable medical x ray equipment, eventually she made her portable van mounted x ray devices soon known as petites curies. She trained many ladies in operating the units. She along with her fleet of portable x ray

units served the French military enormously during the war. Roughly one million allied soldiers received Xray examination in various war fronts. The making and designing of portable Xray units in that period was really challenging due to technological and structural limitations but her will crossed over all the hurdles, Marie Curie assembled many petites curies, a real testimonial for her intellectual outwardness.

The Great of all time left the scene in the year 1934 at the age of 66 in a sanatorium in Passy, France. Her relentless association with ionising radiation over the years rendered her highly vulnerable to radiation induced difficulties which were quite unknown during her period. She became fragile and weak towards end of her life. Many specialists failed to diagnose what exactly happened to Marie. The doctors suspected tuberculosis, but a medical specialist from Geneva hinted out the possibility for a blood disorder for her illness. She died on July 4, 1934. "The disease was an aplastic pernicious anaemia of rapid, feverish development. The bone marrow did not react, probably because it had been injured by a long accumulation of radiations." the sanatorium director reported.

In short, she was the first person dealt with manmade and natural radiation alike, she always wanted her intellectual breakthroughs to have a good and lasting impact in the society she belongs, the Curies provided radium for the first brachytherapy programme in the year 1901. Radiation therapy in fact had a sizzling start then onwards. The continued use of mobile x ray units in field hospitals contributed enough radiation damage to Marie who already had a lot in that sense during the research journey started from pitchblende, then to Polonium and Radium. The cumulative effect of ionising radiation of different origin eventually culminated

into a bone marrow disorder which she succumbed to.

The Curies buried twice seems bizarre but it happened so. Marie laid to rest on July 6th, 1934 beside Pierre Curie in their family grave in Sceaux near Paris. On sixth April 1995 the then French government made the decision to transfer the remains of Curies to national museum Pantheon in Paris as an honour to their contributions not only to France but to the entire humanity. The French president's office directed that radiation measurements and air sampling should be done out of the suspicion that there may be still radiation contamination emanating from the remains. The French radiation protection agency had overseen the retrieval of remains from the grave, safe guarding the workers involved. Upon lifting the tombstone, the wooden coffin with signs of decay was visible but the metal piece holding the name was intact and made the identification easy. The workers then opened the wooden coffin, inside that they saw an intact lead coffin inside which the body of Marie Curie can be seen without much damage! The exhumation of Pierrie followed but the workers could only find some dust and bones. The workers then transferred the precious remains to new coffins and transferred to Pantheon, the French National Museum. On 20 April 1995 a ceremonial re burial of Curies happened the great doors of Pantheon was opened, both laid to rest once again and became the part of elite French History, the nation paid back heavily to the intellectual giants dedicated their lives to scientific research.

W.C Rontgen the father of Radiology is remembered every year by the radiology world through the observance of the international day of radiology, no such day of observance is not assigned till this date to the Great Madame Curie, the founding thoughts of many things emanated from her simple humble brain out of love towards the society she belonged we are still enjoying her innovations that drained her blood, Let us try to put a DAY to remember the Magic Lady, Madame Cuire.

Cardiac Imaging: From the Early Days to Photon-Counting CT

Firdous Nazir,
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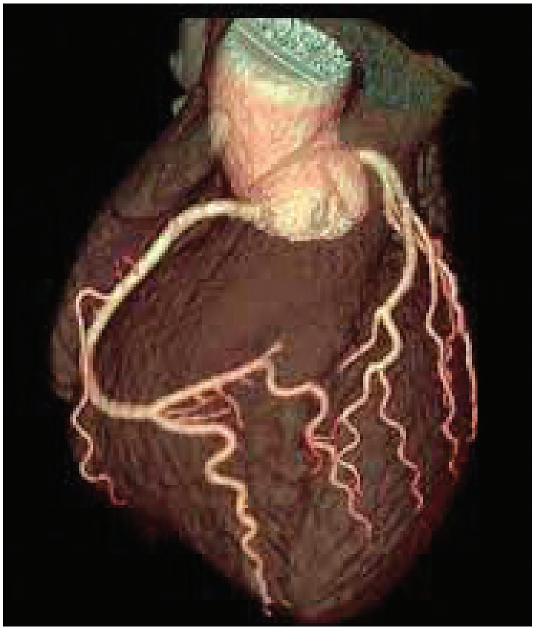


The heart, a remarkable organ, tirelessly beats to sustain life. Throughout history, understanding its function has been a fascination for humanity, sparking the evolution of tools and techniques to visualize it. From rudimentary anatomical sketches to modern photon-counting computed tomography (CT), cardiac imaging has undergone transformative changes, shaping the diagnosis and management of cardiovascular diseases. This article explores the journey of cardiac imaging, from its nascent stages to the cutting-edge technologies of 2024.

The Early Days of Cardiac Imaging

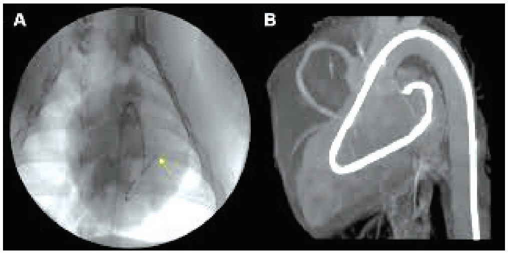
Anatomical Drawings and Auscultation- The first steps in cardiac imaging were purely observational. Pioneers like Leonardo da Vinci meticulously sketched the anatomy of the heart, providing a foundation for future understanding. These anatomical insights were the earliest forms of "imaging," albeit without any visualization of a live, functioning heart. By the 19th century, René Laennec's invention of the stethoscope introduced a non-invasive way to assess heart function. While auscultation was not imaging in the modern sense, it marked a shift towards understanding the heart without direct visualization.

Radiographic Revolution: The Birth of X-rays

The discovery of X-rays by Wilhelm Roentgen in 1895 revolutionized medical imaging. For the first time, clinicians could peer inside the body without surgery. In cardiac imaging, early X-rays were used to detect changes in heart size or pulmonary congestion due to heart failure. However, these static images lacked the dynamic visualization necessary to assess heart function. To address this limitation, fluoroscopy emerged. This technique allowed real-time imaging of the heart and surrounding structures. Despite its promise, the resolution and contrast of early fluoroscopy systems were limited, leaving room for further innovation.

The Rise of Advanced Techniques

Electrocardiography and Cardiac Catheterization- The early 20th century saw complementary advancements in cardiac diagnostics. Electrocardiography (ECG), introduced by Willem Einthoven in 1903, provided crucial insights into the electrical activity of the heart, indirectly supporting imaging findings. In parallel, cardiac catheterization, pioneered in the 1940s, enabled direct visualization of blood vessels using contrast media. This invasive technique marked the dawn of angiography, where coronary arteries could be imaged using X-rays. Despite its invasiveness, it became a gold standard for diagnosing coronary artery disease.



Ultrasound: Imaging with Sound Waves

The 1950s introduced echocardiography, a non-invasive technique that transformed cardiac imaging. By utilizing sound waves, ultrasound created moving images of the heart in real time. For the first time, clinicians could visualize heart chambers, valves, and wall motion dynamically. Initially, M-mode echocardiography was the primary modality, providing one-dimensional images. Over time, two-dimensional (2D) and Doppler echocardiography were developed, allowing detailed assessments of heart function and blood flow. By the 1980s, transesophageal echocardiography (TEE) provided high-resolution images by placing the ultrasound probe closer to the heart.

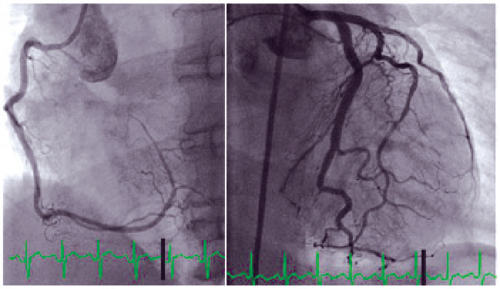
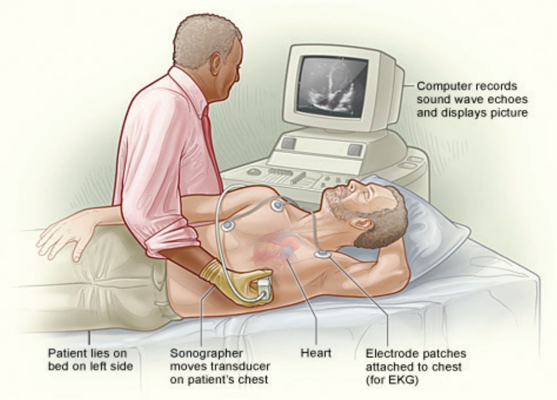


Figure 1: Coronary angiogram depicting the right and left coronary arteries.



Nuclear Cardiology: A Window into Function

Nuclear cardiology gained momentum in the 1970s with the advent of single-photon emission computed tomography (SPECT) and positron emission tomography (PET). These techniques offered a unique ability to assess myocardial perfusion, viability, and metabolism, complementing structural imaging. By injecting radioactive tracers like thallium-201 or technetium-99m, clinicians could detect areas of ischemia or scarring. PET, although less common due to its cost, provided unparalleled accuracy in measuring myocardial blood flow.

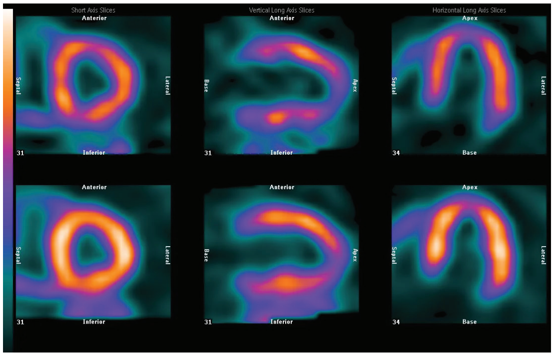
The CT and MRI Era: Precision and Clarity

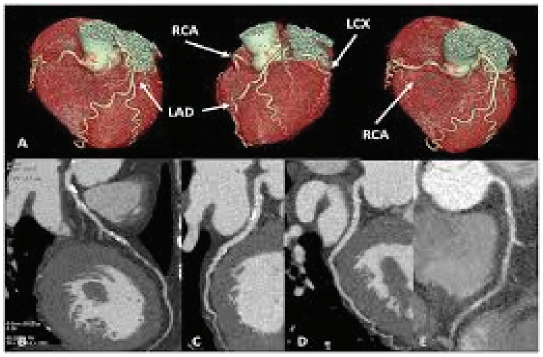
Computed Tomography (CT): The Game Changer

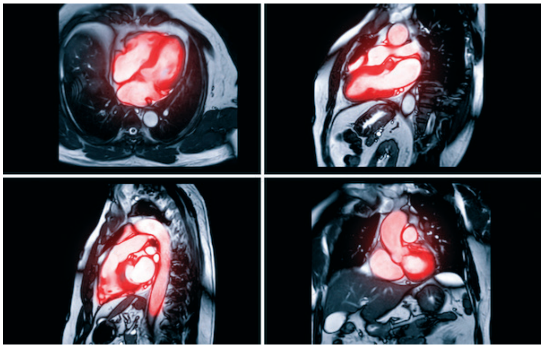
The introduction of CT in the 1970s was a game changer for cardiac imaging. Early CT scanners were slow and had poor spatial resolution, limiting their application in cardiology. However, the development of multi-detector CT (MDCT) in the late 1990s changed the game. With MDCT, high-speed and high-resolution imaging became possible. Coronary CT angiography (CCTA) emerged as a non-invasive alternative to traditional angiography, allowing detailed visualization of coronary arteries. Over the years, innovations like dual-source CT and iterative reconstruction techniques improved image quality while reducing radiation exposure. By 2020, CT had become a cornerstone of cardiac imaging, capable of assessing coronary artery disease, cardiac function, and even myocardial perfusion.

Magnetic Resonance Imaging (MRI): A Comprehensive Tool

Cardiac magnetic resonance imaging (CMR) entered the scene in the 1980s, offering unparalleled tissue characterization. Unlike CT, which relies on X-rays, MRI uses magnetic fields and radio waves, making it radiation-free. CMR excels in evaluating myocardial viability, fibrosis, and complex congenital heart disease. Techniques like late gadolinium enhancement (LGE) revolutionized the assessment of myocardial scarring. By 2024, CMR remains a gold standard for diagnosing conditions like myocarditis, cardiomyopathies, and







valvular diseases.

Photon-Counting CT: The Future Is Here

The Technology Behind Photon-Counting CT Photon-counting CT (PCCT), the latest advancement in CT technology, represents a quantum leap in cardiac imaging. Unlike conventional CT detectors, which measure the total energy of X-rays, PCCT detectors count individual photons and their energy levels. This allows for improved spatial resolution, reduced noise, and better tissue differentiation.

Applications in Cardiology

PCCT has revolutionized cardiac imaging by offering superior visualization of coronary arteries, even in patients with calcified plaques or stents. Its ability to differentiate between different tissue types enhances the assessment of myocardial perfusion and fibrosis. Moreover, PCCT achieves these advancements with significantly lower radiation doses, addressing a long-standing concern in CT imaging.

Challenges and Ethical Considerations

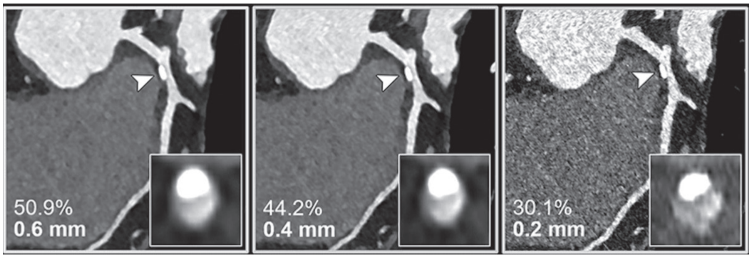
Despite its promise, cardiac imaging is not without challenges. The high cost of advanced modalities like CMR and PCCT limits accessibility in many parts of the world. Ethical concerns also arise regarding overuse and incidental findings, which can lead to unnecessary interventions. As technology advances, balancing innovation with equitable access and patient-centered care remains crucial.

The Human Touch in Cardiac Imaging

Throughout its evolution, cardiac imaging has been more than just technological advancements; it has been about improving lives. From the anxious patient undergoing a coronary CT angiogram to the child with congenital heart disease benefiting from CMR, these innovations are grounded in humanity. As we embrace new technologies, the human element—empathy, precision, and patient care—must remain at the heart of cardiac imaging.

Conclusion

Cardiac imaging has come a long way, from the rudimentary sketches of the Renaissance to the high-tech photon-counting CT of 2024. Each milestone reflects humanity's relentless pursuit of knowledge and innovation. As we look to the future, the focus must remain on harnessing these advancements to improve patient outcomes, making cardiac imaging not just a testament to technological progress, but a beacon of hope for millions.



Integrating Neural Networks With Advanced Optimization Techniques For Accurate Kidney Disease Diagnosis

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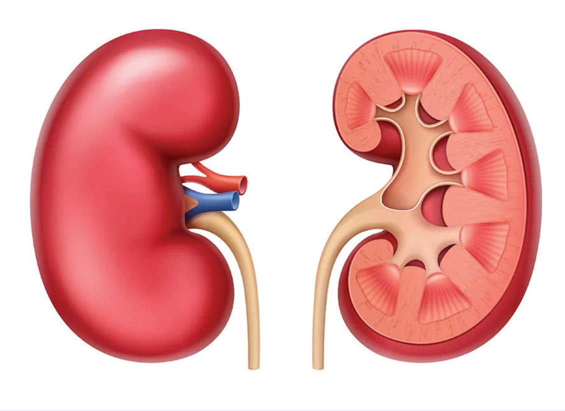
Kidney diseases have emerged as a significant global health concern, with chronic kidney disease affecting over 10% of the world's population. This condition, predicted to rise to the fifth leading cause of death by 2040, underscores the pressing need for effective control measures. Among the prevalent kidney ailments impeding normal renal function, kidney cysts, nephrolithiasis (kidney stones), and renal cell carcinoma (kidney tumor) pose substantial threats. Kidney cysts, fluid-filled pockets on the kidney's surface, and nephrolithiasis, involving crystal concretion formation, impact approximately 12% of the global population. Renal cell carcinoma is identified as one of the top ten most common cancers worldwide. There are different types of data that researchers handled it; Text and images. Text datasets Also often contain valuable information derived from medical records, pathology reports, and patient histories, which can be leveraged to train machine learning models.



Also, diagnostic tools such as X-ray, computed tomography (CT), B-ultrasound, and magnetic resonance imaging (MRI) play crucial roles in conjunction with pathology tests for accurate kidney disease diagnosis. CT scans, particularly valuable for their three-dimensional insights and detailed slice-by-slice imaging, offer a comprehensive understanding of kidney anatomy. Recognizing the urgency of addressing these challenges, the advancement of deep learning in vision tasks presents a compelling opportunity. Building artificial intelligence (AI) models capable of efficiently detecting kidney radiological findings has become imperative to assist medical professionals and alleviate the suffering of individuals affected by kidney diseases. While some studies have explored this domain, the scarcity of publicly available datasets remains a hindrance. Furthermore, past research has often relied on traditional machine learning algorithms, focusing on the classification of single disease classes, such as cysts, tumors, or stones, and occasionally utilizing ultrasound images. In light of these considerations, there is a growing need to expand the scope of AI applications, leveraging deep learning advancements for a more comprehensive approach to kidney disease detection.

Feature concatenation

Feature concatenation plays a crucial role in enhancing the effectiveness of deep learning models, especially in tasks such as image classification. By combining different types of features extracted from diverse sources, feature concatenation enables the creation of a more comprehensive and informative representation of the input data. This process allows the model to leverage complementary information embedded in various aspects of the data, such as color, texture, or spatial features. Unlike traditional single feature approaches, feature concatenation enables the model to capture a richer set of characteristics, potentially improving its ability to generalize and make accurate predictions. Moreover, this technique facilitates the integration of information from different modalities or feature extraction methods, leading to a more ro-bust and nuanced representation. In essence, feature concatenation serves as a powerful tool for refining the input representation, contributing to the model's overall performance and its capacity to handle complex patterns and relationships within the data.

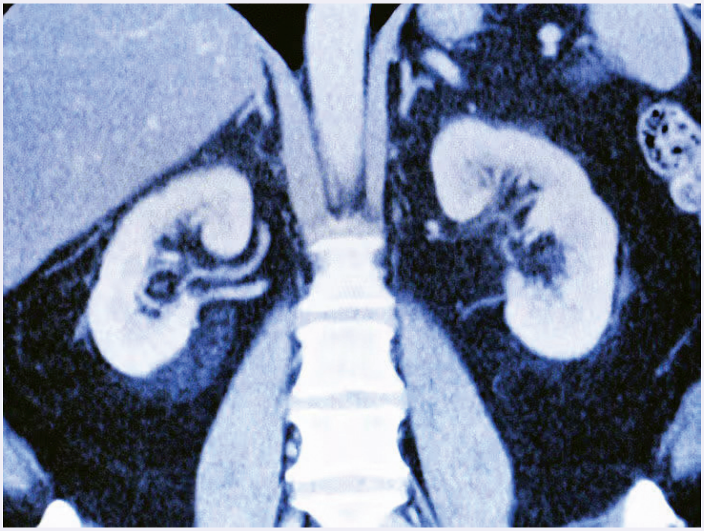
The main contributions of this study are as follows

- Novel classification method: the paper proposes a new approach for classifying kidney diseases that demonstrates robust performance across various datasets, emphasizing the im-

Literature reviews

Reference	Year	Models	Dataset	Evaluation
Parakh et al.	2019	Combined CNN	A specific dataset derived from a hospi-tal's repository of CT scans	Accuracy = 95
Kuo et al.	2019	ResNet	4505 high-quality images with annota-tions measuring kidney size, filtered from 1446 uniquely identifiable primary so-nographic studies of 1299 patients	Accuracy = 85.6%
Sudharson et al.	2020	Ensemble learning using ResNet- 101, ShuffleNet, and MobileNet-v2	Collected dataset of 5490 images	Accuracy = 95.58
Aksakallı et al.	2021	Convolutional Neural Network (CNN)	221 kidney x-ray images obtained from the Urology Department of Ataturk Uni-versity	Accuracy = 83.5
Liu et al.	2022	ResNeXt-50-324d is	C-NMC dataset	Accuracy = 96.83
Srivastava et al.	2022	machine learning models (SVM, KNN, Random Forest, Decision Tree, AdaBoost)	The Indians Chronic Kidney Disease (CKD) dataset consists of 400 instances and 24 attributes with 2 classes	Accuracy = 98.75, 100% Sensitivity, 96.55% Specificity
Baygin et al.	2022	ExDark19 model	1799 CT images	Accuracy= 99.22%
Nazmul Islam et al.	2022	Swin Transformer	12,446 CT images	Accuracy=99.3, precision and recall reaching 99.15%, 99.15%,respective ly with 0.99987 AUC
Subedi et al.	2023	ViT + FCN	12,446 CT images	Accuracy = 99.64
Asif et al.	2023	StoneNet	1799 CT images	Accuracy = 97.98%
Qadir et al.	2023	Densenet-201 model	12,446 CT images	Accuracy = 99.719
Sasikaladevi et al.	2024	HCNN	12,446 CT images	Accuracy = 99.71
This study	2024	Alex + ConvNexT	12,446 CT images	Accuracy = 99.85, precision, recall, and specificity reaching 99.89%, 99.95%, and 99.83% respectively

***Table 1**. Related work in kidney classification using different datasets.*



Several factors contribute to the motivation for kidney classification research:

Clinical Importance: Diagnosing kidney disorders accurately can be challenging due to their wide range of etiologies and symptoms. Enhancing classification techniques helps medical professionals better comprehend various kidney disorders and customize treatment plans based on individual disease profiles.

Early Identification and Intervention: It's critical to identify kidney disorders early to launch prompt interventions that can halt the disease's progression and enhance patient outcomes. Classification models can help detect kidney function issues early on, which can result in more proactive and focused medical interventions.

Application of Advanced Technologies: The development of complex models for the classification of renal disease is made possible by advances in machine learning, deep learning, and image processing techniques. Making use of these technologies has the potential to completely transform how accurate and effective diagnostic procedures are.

portance of interpretability and explainability for clinical applications.

- ***Advanced integration of neural networks:*** this study integrates features from AlexNet and ConvNexT to create a comprehensive and informative feature representation. This fusion leverages the strengths of both architectures, resulting in superior performance compared to individual models.
- ***Enhanced model performance:*** By combining AlexNet and ViT, the paper achieved improved discriminative ability, capturing a broader range of visual features and surpassing the performance of the individual models.
- ***Optimized training process:*** this study introduced a custom optimization technique based on Adam that dynamically adjusts the step size according to the gradient norm, leading to more efficient convergence in training the merged AlexNet and ConvNexT models.

Motivation

The urgent need to improve patient care and medical diagnostics in the field of renal health is the driving force behind the kidney classification paper. Kidney illnesses are a major global health concern, encompassing both acute and chronic ailments. Timely and accurate categorization of these ailments is essential for efficient treatment strategy development and patient supervision.

Proposed methodology

The paper discusses the impact of the concatenating features for enhancing the accuracy of kidney disease classification using the merging of Alex-Net with other models such as (ViT, Swin, and ConvNexT) and also the impact with using the modified Adam optimizer "Custom-Adam" instead of the popular optimizer "Adam".

The paper compared its performance with more recent architectures such as VGG and ResNet. The results show that the pre-trained VGG and ResNet models achieved accuracies of 91.73% and 94.63%, respectively. In contrast, more advanced models such as Vision Transformer (ViT), Swin Transformer, and ConvNexT achieved higher accuracies of 98.71%, 96.44%, and 96.44%, respectively. These findings highlight the superior performance of these newer architectures over

Alex-Net. While Alex-Net has a well-established reputation in image classification tasks as its architecture is known for efficient feature extraction, which is crucial for accurately classifying kidney diseases from medical images.

Transformer models which include ViT and Swin have demonstrated remarkable performance in various computer vision tasks, particularly in capturing long-range dependencies and spatial relationships within images. For example, the main purpose for using the ViT model is self-attention mechanism allows it to capture global contextual information in images, enabling it to identify complex patterns and long-range relationships. But Swin optimizes the attention computation in Vision Transformers by limiting self-attention to non-overlapping local windows. This shifted window approach reduces the normally quadratic complexity of ViT to linear complexity concerning image size, making Swin more computationally efficient. Also, Swin is a hierarchical vision transformer that progressively merges adjacent patches as the network deepens. This hierarchical structure enables the model to manage features at various scales, enhancing the learning of robust and discriminative features compared to convolutional neural networks. But with ConvNexT model, incorporates modern techniques like hierarchical design and larger kernel sizes, enhancing its ability to handle diverse image features while maintaining the simplicity of traditional CNNs. The paper included these models to explore their potential to extract relevant features from medical images, which could contribute to improving diagnostic accuracy.

On the other side, changing the optimizer can significantly impact model accuracy, convergence speed, generalization ability, and overall stability. Therefore, choosing the right optimizer is crucial for optimizing machine learning models. The paper compared the effect of Adam and Custom_Adam optimizer on the dataset to find the Custom_Adam is better in most cases while the primary difference between the standard Adam optimizer and the Custom_Adam lies in the additional calculation and utilization of the gradient norm in the custom version. Specifically, Custom_Adam computes the norm of the gradient (denoted as norm value) for each parameter θ with a non-None gradient:

Norm value = $\|gt\|$ (1)

This norm is then used in the custom update rule. The update rule method in Custom Adams incorporates this norm value along with the parameter θ, gradient gt, and state during the update process, which can be expressed as:

$\theta_t+1 = \theta_t - \alpha/m_t * \sqrt{(v\ t\ )}/(normvalue+\epsilon)$ (2)

The parameter update in the standard Adam is as:

$\theta_t+1 = \theta_t - a/(\sqrt{(v_t\ )}+\epsilon)* m_t$ (3)

Additionally, Custom Adam overrides the step method to include the gradient norm calculation and the call to the _update rule, whereas the standard Adam optimizer utilizes its default step method without these extra computations. This enhancement allows Custom Adam to adapt the learning rate based on the gradient's scale, potentially improving optimization performance. See the algorithm as the following.

Input:

- params: Model parameters
- lr: Learning rate (default: 1e-4)
- betas: Tuple of beta1 and beta2 values (default: (0.9, 0.999))
- eps: Epsilon value for numerical stability (default: 1e-8)
- weight decay: Weight decay (default: 0)

1. Initialize custom Adam class:

Call optim. Adam constructor with provided parameters.

2. Override step method:

If closure is provided, calculate loss using closure.

Iterate over parameter groups:

2.2.1 Iterate over parameters in the group.

2.2.1.1 If the gradient is not None:

2.2.1.1.1 Calculate norm value using torch. norm.

2.2.1.1.2 Call _update rule method with parameter, gradient, state, and norm value.

3. Define update rule method:

3.1 Increment the step counter in the state.

3.2 Compute exponential moving averages for the first and second moments.

3.3 Calculate bias correction terms.

3.4 Update parameters using the Adam update rule with the adjusted step size.

4. End

Algorithm: Custom Adam

To accomplish this, the two actions listed can be taken: first; compare using four single vision models (ViT, Alex-Net, Swin, and ConvNexT) for extracting the features from images by using the optimizer Adam and the Custom Adam. The second is to improve the extracting feature process using the concatenating features from the four vision models with the best optimizer that got from the first action; the vision models are ("Swin + ConvNexT", "Alex-Net + ViT", "Alex-Net + Swin" and "Alex-Net +ConvNexT"). The paper finds that concatenating the models Alex-Net with ConvNexT with Custom_Adam optimizer is the best value in accuracy 99.85% with metrics used for the evaluation such as average precision, recall, and specificity, reaching 99.89%, 99.95%, and 99.83% respectively.

The methodology of this study for kidney classification involves several steps

Image loading from the directory is then applied using T. Compose to augment the training data, these transformations include random horizontal and vertical fips, random color jitter, resizing to 256 * 256 pixels, center cropping to 224 * 224 pixels, conversion to a PyTorch tensor, normalization using ImageNet mean and standard deviation, and random erasing with a probability of 0.1.

Load pre-trained models (AlexNet and ConvNexT) then freeze the parameters of the loaded models and create a new model by concatenating the output features of the two models and then adding a classifier layer.

Define a custom optimizer class that inherits from Adam with the modifications.

Define functions to get data loaders for training and validation then implement data loading and augmentation for the training set and the validation set.

Define the training loop using the optimizer and the loss "Cross Entropy Loss".

Evaluate the model using the confusion matrix and the learning curve for the loss and accuracy.

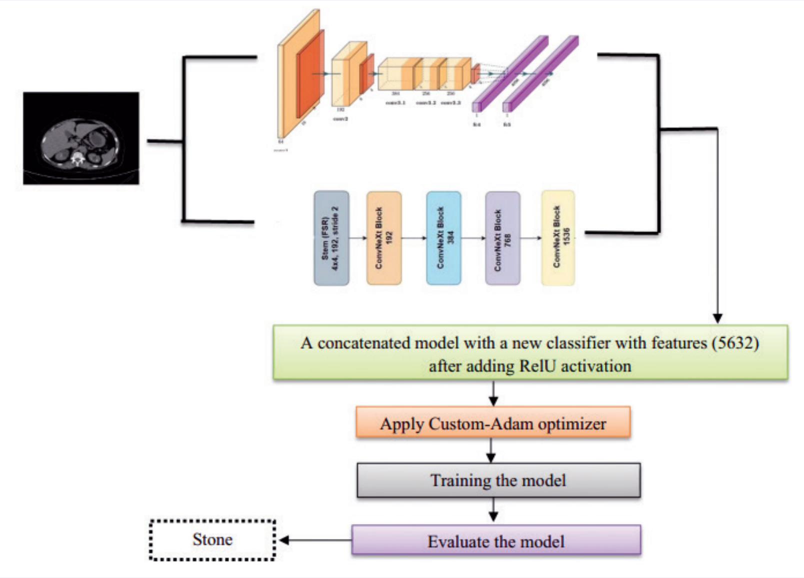


Fig.1. *The methodology of this study for kidney classification*

Dataset

The paper used the dataset that originated from various hospitals in Dhaka, Bangladesh, where patients had previously received diagnoses related to kidney tumors, cysts, normal conditions, or stone findings. Te gathered data from the Picture Archiving and Communication System (PACS), incorporating both Coronal and Axial cuts from contrast and non-contrast studies covering the entire abdomen and urogram. Subsequently, patient information and metadata were excluded from the Dicom images, and the images were converted to a lossless jpg format. To ensure accuracy, each image finding underwent verification by both a radiologist and a medical technologist after the conversion process. The dataset contains 12,446 unique data within it which the cyst contains 3709, normal 5077, stone 1377, and tumor 2283. The sample of the dataset used.

Experiments and results

This study used the assembled and annotated 12,446 CT whole abdomen and urogram images

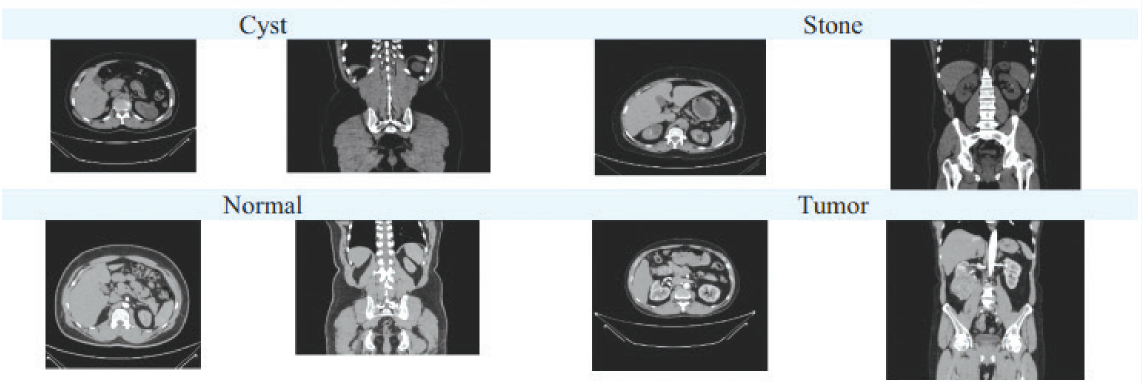


Fig.2. *Sample image from the dataset*

that contained four classes Cyst, Normal, Stone, and Tumor. The paper divided the dataset into training and validation using augmentation to overcome the overfitting problem such as Random Horizontal Flip, Radom Vertical Flip, Center Crop, and Normalize the images. After augmentation training dataset be 19,450 instead of 9725 and the validation be 5442 instead of 2721.

The hyperparameter settings for the best model (Alex-NeT + ConvNexT with custom-Adam optimizer) are as follows: learning rate with 1e-4, Epochs=100, loss=CrossEntropyLoss, Optimizer=custom-Adam and batch size=32. The paper trained the models using Pytorch with a laptop with one GPU (2060 RTX).

Performance evaluation methods

The evaluation of the eight models involves an analysis based on parameters such as accuracy in training, sensitivity (or recall), and precision (or positive predictive value - PPV). To calculate precision, and Recall, the paper utilizes true positive (TP), false positive (FP), true negative (TN), and false negative (FN) samples. Recall, also known as sensitivity, is determined by dividing the number of true positives by the sum of true positives and false negatives. In medical diagnosis, high recall is imperative for accurately identifying individuals with the disease, as overlooking the positive category can result in serious consequences like misdiagnosis and treatment delays. Precision (PPV) becomes crucial when assessing the proportion of predicted positive examples that are genuinely positive. Precision is calculated by dividing the number of true positives by the sum of true positives and false positives. In the realm of medical imaging, achieving high precision is highly desirable. The F1 score for all models is derived from the sensitivity and precision values. The provided formulas are applied to calculate accuracy, precision, sensitivity, and the F1 score.

Percisioni = (TP_i)/(TP_i+FP_i) (4)

Recalli = (TP_i)/(TP_i+FN_i) (5)

F–scorei = (2*Perision_i*Recall_i)/(Perision_i+Recall_i) (6)

where, i=class of the kidney (Cyst or Normal or Stone or Tumor), TP= True Positive, FN= False Negative, TN=True Negative.

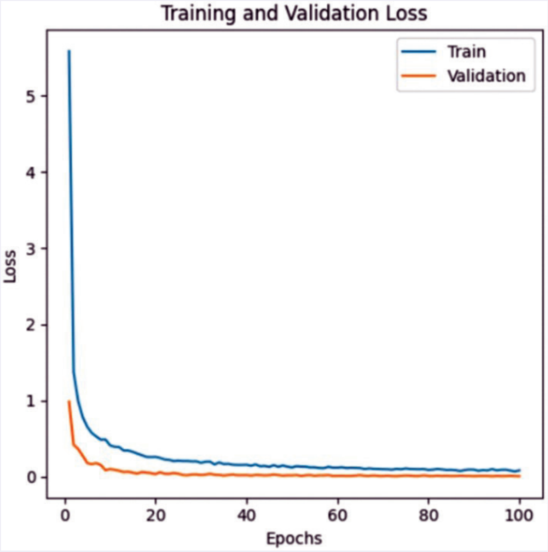


Fig. 3. *Training and Validation Loss.*

No. parameters of different models

One essential feature that greatly affects a neural network model's capacity, efficiency, and flexibility is the number of parameters. Deep learning models consist of several layers, each of which has weights and biases that add to the total number of parameters. Greater representational capacity is often possessed by larger, more parameterized models, which allows them to learn complex characteristics and relationships in data. Conversely, more compact models with fewer parameters could be less prone to overfitting and more computationally efficient, which makes them appropriate for jobs requiring sparse data. The total number of parameters and trainable parameters for the single models and the concatenated models used in this paper. It's generally more meaningful to focus on "Trainable parameters" rather than "Total number of parameters." because not all parameters in a model may be trainable, as some might be fixed or non-trainable. The model with the least parameters is Swin, and the model with the most parameters is Alex-Net + ConvNexT. Larger parameter counts are often associated with better model accuracy, so the progression from the model with the least parameters to the most parameters could represent an increase in model capacity and, potentially, accuracy.

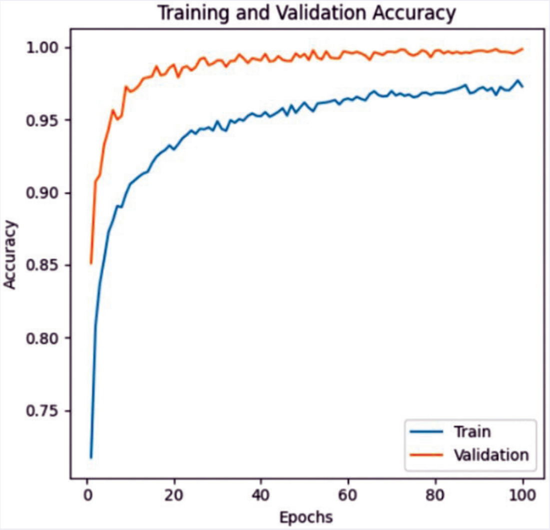


***Fig. 4.** Training and Validation Accuracy*

Time evaluation

For each of the 8 tested single models, the study compared the time taken for training for each model to get the less time that was taken. Alex-Net with Adam optimizer was the fastest in training as it took the least training time (50 minutes) with an accuracy of 96.32 followed by Swin with Adam optimizer which took 59 minutes with an accuracy of 96.44 then Alex-Net+ custom Adam that took 66 minutes with accuracy 96.91 while the best one which is ViT with Adam optimizer took 5 hours approximately with accuracy 98.71 while the ConvNexT with custom Adam optimizer took the longest time with around 10 hours with an accuracy of 96.62.

The concatenated models for each of the 8 tested concatenated models, the paper also compared the time taken for training for each model to get the less time that taken., Swin +Alex-Net with custom Adam optimizer was the fastest in training as it took the least training time (2 h and 30 min) with an accuracy of 99.78 followed by Swin+ConvNexT with Adam optimizer which took around 3 h and a half with an accuracy of 99.12 while ConvNexT+Alex-Net, Swin+Alex-Net with Adam optimizer and Swin+ConvNexT with custom Adam optimizer took the same time around 4 h and a half with accuracies 99.63, 99.45 and 98.75 respectively. The best one which is ConvNexT+Alex-Net with cuatom_Adam optimizer took 6 h approximately with an accuracy of 99.85. While the Alex-Net+ViT with custom Adam optimizer took the longest time around 7 h with an accuracy of 99.74.

Conclusions

This study explored the impact of feature concatenation and optimizer selection on neural network performance. The experimental results reveal that concatenating features, such as Alex-Net+ConvNexT, in combination with the custom Adam optimizer, achieved an impressive accuracy of 99.85%. This highlights the benefits of integrating diverse model architectures and optimizing strategies to capture complex patterns and correlations in data. The custom Adam optimizer demonstrated superior performance compared to the standard Adam optimizer across all concat-

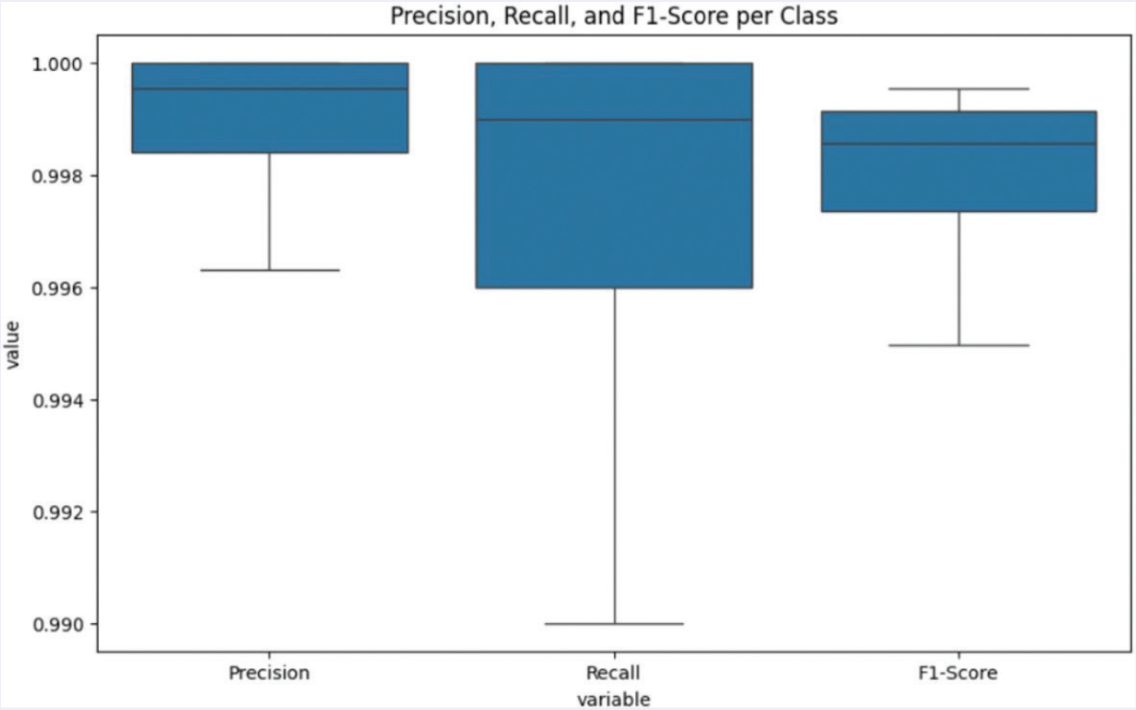


Fig. 5. *Precision, Recall, and F1-score for Alex-NeT + ConvNexT with custom-Adam optimizer.*

enated models, excelling in accuracy, precision, recall, and F1-score. Particularly notable was its effect when paired with Transformer models, where dynamic step size adjustments based on gradient norms contributed to consistently high average recall and accuracy. The trade-off between model capacity and efficiency was evident, with the Swin model, despite its fewer parameters, performing competitively. This underscores its utility in scenarios where computational efficiency and reduced overfitting are critical. While larger models like Alex-Net+ConvNexT exhibited higher accuracy, the Swin+Alex-Net combination offered a balanced approach with a training duration of 2 h and 30 min and an accuracy of 99.78%. Conversely, the Alex-Net+ViT configuration, though achieving 99.74% accuracy, required the longest training time of approximately 7 hours.

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PSYCHORADIOLOGY

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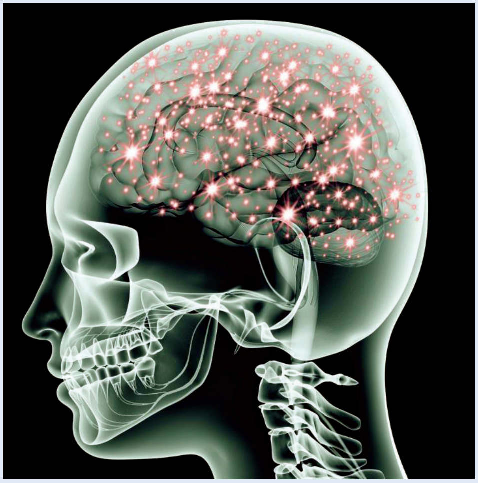
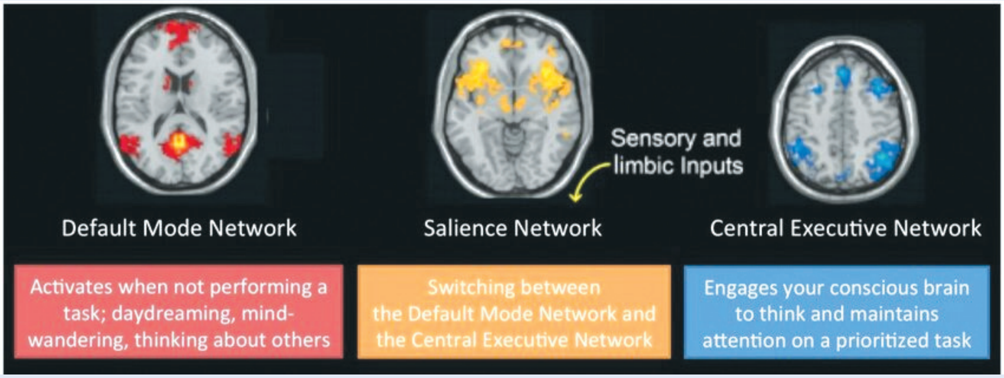
Many studies have shown that psychiatric medications induce specific measurable changes in brain anatomy and function that are related to clinical outcomes. As a result, a new field of radiology, termed psychoradiology, seems primed to play a major clinical role in guiding diagnostic and treatment planning decisions in patients with psychiatric disorders. Psychoradiology is a term that describes a growing intersection between the fields of psychiatry and radiology, and it is an emerging branch of radiology that is closely associated with neuroradiology and neurology.

In clinical practice, psychoradiology indicates the use of radiologic approaches in patients with major psychiatric disorders and spans from diagnosis to treatment planning and monitoring.

One of the greatest difficulties in diagnosing and treating psychiatric disorders is that human behaviours are complex; thus, psychiatric disorders can be difficult to study in animal models when trying to understand the pathogenesis. These challenges have slowed progress in psychiatry as a field of clinical medicine; however, in recent decades, progress primarily from clinical brain imaging but also from human postmortem brain studies and genetic research has greatly increased biologic understanding of the neural substrate of these conditions. Although psychoradiology is not yet validated to the degree necessary for clinical practice, it is a rapidly evolving field and one in which the active involvement of radiologists will be important to ensure its success. MRI for psychiatric applications had been emphasized. The term was selected to parallel that of the field of neuroradiology, and to reflect the evolution of the research field of psychiatric neuroimaging to a new medical practice discipline. The potential clinical utility of using brain structural and functional imaging to investigate cerebral alterations in psychiatric disorders has been demonstrated in hundreds of MRI studies of major psychiatric disorders including schizophrenia and depression. Psychoradiology has developed to utilize radiological imaging approaches for differential diagnosis and individualized patient care for psychiatric illnesses. Given the high prevalence of psychiatric disorders, this is particularly important, where the development of the multimodal MRI has allowed quantification of brain characteristics at the structural, functional and molecular level. Neuropsychiatric disorders likely represent a complex interplay between biological, psychological and social factors. The final common pathway to psychiatric symptoms is usually an interaction between vulnerability and psycho-social factors, with disease vulnerability coming from several sources such as genetic/epigenetic factors, developmental insult (biological and/ or psychological), acquired brain insult (traumatic, vascular, toxic, infectious etc.), or neurodegeneration. This is mainly due to the low specificity of several biomarkers investigated, rendering them less useful in identifying disorders, predicting disease progression or treatment responses. biomarker is defined as "a characteristic that is objectively measured and evaluated as an indicator of normal biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention". For some disorders with neuropsychiatric aspects like Huntington's disease, genetic biomarkers can predict the diagnosis with nearly perfect certainty.

Despite current understanding of some mental illnesses like schizophrenia as being highly heritable, no reliable genetic biomarker with a clear link to disease mechanism has been identified. Multiple factors contribute to neuropsychiatric disorder susceptibility. These factors include genetic predisposition, developmental insult, brain injury and natural (or disease-state) aging. Together these factors can influence the molecular, physiological and structural characteristics of the brain. The wide clinical availability of brain imaging modalities such as computed tomography (CT) and later magnetic resonance (MR) imaging resulted in a tremendous amount of literature on brain structure abnormalities in neuropsychiatric disorders. However, a recent meta-analysis of structural imaging studies identified gray matter loss in dorsal anterior cingulate and the insula that was common across six distinct diagnostic groups (schizophrenia, bipolar disorder, depression, addiction, obsessive-compulsive disorder, and anxiety), with only few specific findings that distinguished depression and schizophrenia from other diagnoses. This highlights the need for a better understanding of the underlying molecular changes that lead to volume loss and differential therapeutic options and highlights the difficulty in identifying specific biomarkers for each disorder by using only structural imaging acquisitions. methods





of anatomical parcellation and image processing have yielded a number of variations in the make-up of these large-scale networks, three specific networks appear to be more consistent than the others. These major core functional networks are thought to be involved in the interface between cognition and emotions and are called the default mode network (DMN), the salience network (SN) and the central executive network (CEN). The DMN is composed of central structures including the medial prefrontal cortex (mPFC) and the posterior cingulate cortex (PCC). The DMN is busy when you are mentally passive or not engaged in a specific task. The CEN includes the dorsolateral prefrontal cortex (DLPFC) and inferior parietal cortex (IPC) and is involved in attention and executive function. Unlike the DMN, the CEN is engaged in higher-order cognitive and attentional control. Lastly, the salience network (SN) is composed of the anterior insula (AI), mainly in the right side, and anterior cingulate cortex (ACC) and is involved in coordinating switching between DMN and CEN based on the individual's needs.

Methodology

Two key features of the brain disorders seen in psychiatry are of special note. Cerebral deficits primarily relate to brain function rather than gross anatomic alterations, and changes are modest, requiring quantitative analysis rather than visual inspection of images. Thus, development and use of non-invasive quantitative methods to observe patterns of structural and functional cerebral changes in patients with psychiatric disorders are the primary tasks of psychoradiology.

1) High - spatial - resolution T1 - weighted structural MR imaging is used to detect alterations in gray matter morphometry, including regional volume, cortical thickness, and shape of gyral and Voxel-based analysis, a computer-based technique that can be used to identify changes in given indexes in any part of the whole brain without a prior hypothesis, is commonly used to explore gray matter changes in patients with psychiatric disorders.

2) White matter deficits are characterized primarily with diffusion-tensor (DT) imaging and magnetization transfer imaging. With DT imaging, MR imaging studies target regions of interest (ROIs), and by using voxel-based analysis and tract-based spatial statistics, investigators have quantified parameters, including fractional anisotropy and mean diffusivity, to identify changes in the physical properties of the fibre bundles, such as packing density, myelination, and axon diameter, in patients with psychiatric disorders.

3) Besides structural MR imaging, functional MR imaging has been widely used to identify brain functional or physiologic abnormalities in patients with psychiatric disorders. On the basis of changes in the blood oxygen level–dependent signal evoked by specific tasks, a large body of literature documents disruptions in sensory, cognitive, and affec-

tive brain circuitry, with task-related change of neural activity reflected by the increase or decrease in the blood oxygen level–dependent signal. Functional MR imaging provides an important non-invasive opportunity to evaluate neuronal activity and neural circuitry in vivo

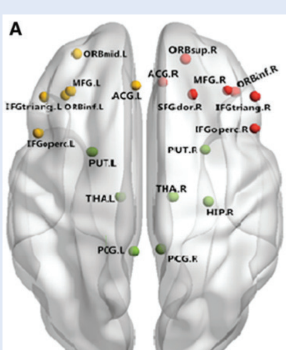
Disorders:

1)Major depressive disorder-

Anatomic and functional deficits are revealed in multiple brain regions in patients with MDD, especially prefrontal-limbic circuits. -analysis of voxel-based morphometry studies of medication-free patients with MDD identified robust gray matter decreases in prefrontal and limbic regions, mainly including the bilateral superior frontal gyrus, lateral middle temporal and inferior frontal gyri, and bilateral para hippocampal gyrus and hippocampus. White matter deficits, especially those revealed by DT imaging, have been observed in patients with mood disorders, mainly within emotion regulation circuitry, this finding is consistent with gray matter findings. For example, patients with depressive disorder exhibited substantially lower fractional anisotropy (FA) values in the white matter of the right middle frontal gyrus, the left lateral occipitotem poral gyrus, and the angular gyrus of the right parietal lobe than did healthy comparison subjects.

Superior view:

Red and yellow spots represent changes in gray matter volume and function, respectively, and green spots identify regions with both functional and anatomic changes. ACG.L = left anterior cingulate gyrus; ACG.R = right anterior cingulate gyrus; HIP.R = right hippocampus; IFGoperc.L = left inferior frontal gyrus, pars opercularis; IFGoperc.R = right inferior frontal gyrus, opercular part; IFGtriang.L = left inferior frontal gyrus, pars triangularis; IFGtriang.R = right inferior frontal gyrus, triangular part; MFG.L = left middle frontal gyrus; MFG.R = right middle temporal gyrus; ORBinf.L = orbital part of left Inferior frontal gyrus; ORBinf.R = orbital part of right inferior frontal gyrus; ORBmid.L = orbital part of left middle frontal gyrus; ORBsup.R = orbital part of right superior frontal gyrus; PCG.L = left posterior cingulate gyrus; PCG.R = right posterior cingulate gyrus; PUT.L = left lenticular nucleus, putamen; PUT.R = right lenticular nucleus, putamen; SFGdor.R = right superior frontal gyrus, dorsolateral; THA.L = left thalamus; THA.R = right thalamus

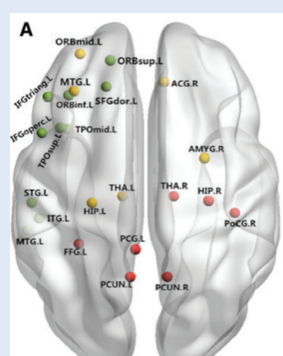


2)Schizophrenia

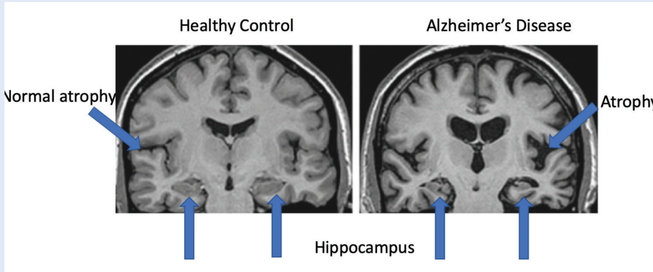
Some relatively recent studies have examined the potential role of imaging features in the clinical diagnosis of schizophrenia. Three studies have shown that volume reduction in prefrontal and temporal regions was the main anatomic difference between patients and control subjects, separating groups with a classification. Circumstantial evidence from MR spectroscopy (MRS) studies indicates that in early stages of schizophrenia, a glutamatergic excess may be seen, which later evolves into a state of glutamatergic deficit.

Neural networks involved in schizophrenia mainly include the prefrontal cortex, temporal cortex, and thalamus

Red and yellow spots represent changes in gray matter volume and function respectively; green spots indicate regions with both functional and anatomic changes

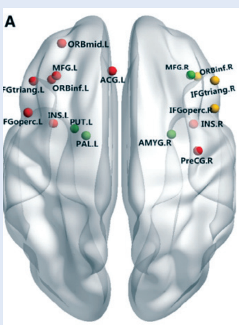


3) Bipolar Disorder



Imaging findings indicate some common cerebral deficits across patients with BD and those with schizophrenia, especially in the approximately 50% of patients with BD who have a history of psychosis. A resting-state functional MR imaging study revealed that both BD and schizophrenia shared regional and connectivity deficits within striatal-thalamo-cortical networks, while patients with schizophrenia showed more and greater regional functional deficits in the thalamocortical systems.

Neural networks involved in BD mainly include the inferior frontal cortex and limbic areas. Red spots and yellow spots represent changes in gray matter volume and function, respectively; green spots indicate regions with both functional and anatomic changes



4)Alzeimer

Only recently have basic mechanism of neuropsychiatric symptoms of AD been studied with neuroimaging. Psychosis studies of AD including delusions and hallucinations have reported volume loss in gray matter of brain areas involved in large-scale brain networks. concluded that the majority of studies implicated right-sided predominance involving mainly frontal areas in paranoid delusions, but involving temporal areas in misidentification delusions. reported hypometabolism (18F-FDG-PET study) in the right lateral frontal cortex, orbitofrontal cortex, and bilateral temporal cortex in patients with delusions and AD.

Future direction:

Several key questions for psychiatry researchers included how to characterize disease-specific neural deficits to understand illness mechanisms, how to develop a neurobiologically based diagnostic system for major mental illness, and how to use mechanistic understanding coupled with new diagnostic classifications based on shared neural system deficits to advance precision medicine. Psychoradiology will play a key role in all three aspects, as findings from psychiatric imaging research are translated to reshape clinical practice.

Conclusion:

Although numerous clinical studies have identified imaging biomarkers for mental disorders and clarified their pathological mechanisms, their capacity to identify the unique structural and functional architecture of an individual's brain is a critical step towards individual-specific brain analysis for psychoradiology. diagnostic biomarkers need to demonstrate utility in the differential diagnostic challenges most frequently encountered in psychiatry, such as schizophrenia vs bipolar disorder, bipolar disorder vs major depression, and ADHD vs high functioning autism vs bipolar disorder in paediatric patients. Additionally, clinical samples will need to be examined, not the relatively confound-free samples used in mechanistic research, but maybe more complex sample with comorbidity which is the real clinical situation. Improvements in quantitative analyses makes MRI an indispensable tool to elucidate the neurobiological substrates that underlie psychiatric illnesses. While longitudinal clinical trials are needed to solidify those findings.

Advancement in MRI Musculoskeletal in Clinical Practice

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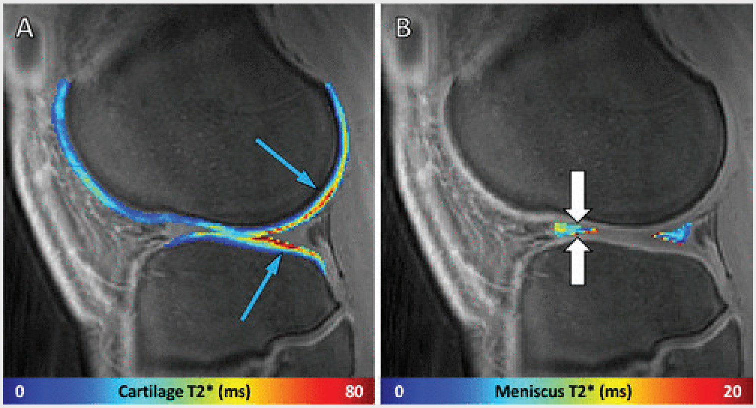
With continuous hardware and software advancements aimed at optimizing image quality and speed, MRI has grown in significance over the past few decades for the diagnosis and long-term monitoring of musculoskeletal disorders. However, a greater focus on efficiency and specificity will be required due to the growing demand for musculoskeletal MRI and growing desire in offering more individualized care. High-channel phased-array coils, stronger gradients, and enhanced wide-bore magnet designs to preserve field homogeneity are examples of ongoing hardware advancements. Improving synthetic MRI and MR fingerprinting techniques is anticipated to receive more attention to reduce acquisition times overall and meet the need for individualized care by concurrently gathering microstructural data that will provide more specific information about the severity of the disease.

Introduction

MRI is already essential for the diagnosis of numerous musculoskeletal conditions, and its application in this area is expected to grow. To visualize soft-tissue and osseous disease without the use of ionizing radiation, modern MRI techniques provide multiplanar and high-spatial-resolution capabilities. MRI offers quantitative data on microstructural architecture and biochemical composition in addition to qualitative evaluation of macrostructural tissue integrity because of its broad dynamic contrast range.



MRI systems had better maximum gradient amplitude (approximately 33 mT/m) and slew rate (approximately 120 mT/m/msec). wide-bore systems (amplitude and 200 mT/m/msec slew rate) launched from 2017 to 2021 offer a larger capacity and gradient amplifiers with peak output to allow for greater gradient performance (150–220 mT/m/msec, 60–80 mT/m).

Enhancing gradient performance is essential for decreasing echo spacing (to minimize blurring), especially for the widely used fast/turbo spin-echo (FSE/TSE) sequences in musculoskeletal MRI. Although the diagnostic performance of 1.5- and 3.0-T musculoskeletal magnetic resonance imaging (MRI) is comparable, the 3.0-T systems' superior signal-to-noise ratio (SNR) efficiency—which is almost twice as high as that of 1.5-T systems—has been utilized to reduce scanning times and/or enhance spatial resolution.

These features make it possible to identify a variety of diseases, such as neoplasms, metabolic disorders, inflammation, degeneration, and acute traumatic injury. To simplify patient care, MRI can be utilized to assess tendon, ligament, and cartilage damage after trauma as well as find fractures that occasionally go undetected on radiography and CT scans. Because of its high sensitivity to damage, MRI can be used to differentiate between acute and chronic ailments and to determine when athletes should return to play after suffering an injury. There will be more needs to be met as the use of MRI in musculoskeletal medicine continues to develop and grow. The concurrent rise in the number of joint replacements performed on the elderly population and increased MRI scanner accessibility worldwide has resulted in to an increase in MRIs of the musculoskeletal system.

Hardware

Magnets and Gradient

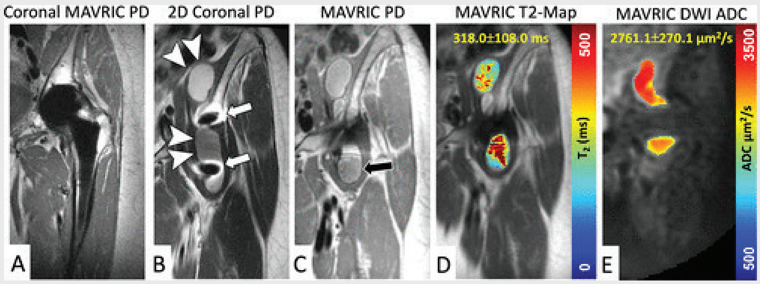
For clinical musculoskeletal MRI, wide-bore (70 cm diameter) 1.5- and 3.0-T MRI systems have become commonplace. Major suppliers provide a range of these devices with different gradient performance. A wide-bore system makes it easier to position the target anatomy closer to the isocentre, where the gradient fields (important for resolution uniformity) and magnetic field (important for water excitation or chemical-based fat suppression), even though B0 and B1 inhomogeneities may be magnified. While 60-cm-diameter systems had roughly 50 mT/m, early wide-bore

Radiofrequency coil

Since musculoskeletal MRI covers various anatomical areas, it is often necessary to use different phased-array coils tailored for each body part to enhance spatial resolution. The quantity of coil elements in commercially offered phased-array coils currently varies from 8 to 72 (Table 1), a rise from the four to 16 coil elements that were available in previous decades. Additionally, it is now possible to combine several coil arrays, and the number of channels available for radiofrequency reception has risen significantly, increasing from 32 or fewer in the past decade to more than 200 in recent commercial systems.

Acquisition and Reconstruction Schemes for Accelerating Musculoskeletal MRI

Over the last 15 years, conventional acceleration techniques for two-dimensional (2D) and three-dimensional (3D) imaging have advanced significantly, encompassing parallel imaging (PI), compressed sensing, and simultaneous multislice (SMS) methods. In all areas of MRI, quick image

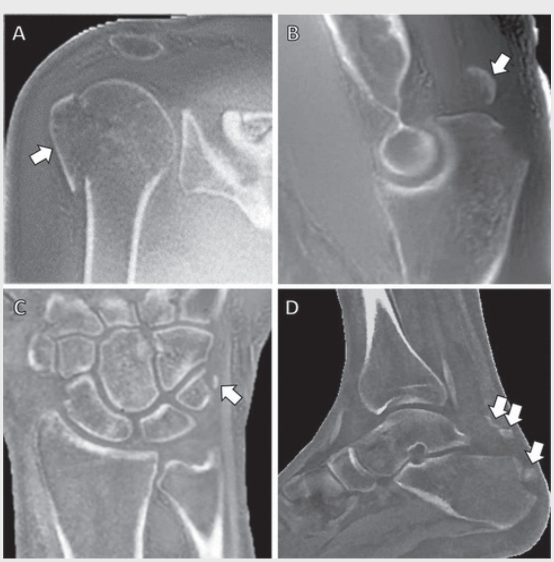


acquisition is greatly appreciated for enhancing efficiency and minimizing motion artifacts. Nowadays, these methods are typically incorporated into 1.5- or 3.0-T musculoskeletal MRI protocols, and in everyday practice, at least a twofold acceleration is frequently used.

Synthetic MRI methods, MR fingerprinting, and DL-based reconstruction algorithms are examples of more recent advanced acceleration approaches that have a great deal of study and practical promise to speed up imaging even more.

"Conventional" Acceleration and 3D Techniques

Traditional acceleration methods have made it possible to use 3D musculoskeletal MRI acquisitions in clinical settings. The formerly lengthy scanning times of isotropic resolution 3D gradient-echo and FSE/TSE sequences can be significantly reduced by fourfold if twofold acceleration is carried out in both phase-encoding directions.



Three-dimensional pulse sequences are frequently accelerated bidirectionally.

Most pulse sequences can now be acquired using image-based and k-space-based PI, compressed sensing, and SMS acquisition (Table 2) techniques, which when combined can result in net four- to eightfold acceleration factors and 80% faster examinations; for instance, a high-quality joint MRI can now be completed in five minutes or less.

Synthetic MRI and MR Fingerprinting

The lengthier scanning times, comparatively lower spatial resolution than qualitative scans, and the challenges associated with implementing quantitative MRI in current clinical practice enhancement of image registration's resilience and precision is required techniques. One intriguing way around these obstacles would be to use synthetic MRI techniques that produce multicontrast images, including quantitative maps, from a single acquisition.

MR fingerprinting is an alternative to synthetic MRI that creates "fingerprints" (a physics-based dictionary) by generating pulse sequences with different settings and parameters (e.g., flip angle, sampling trajectory) throughout the acquisition in a pseudorandom manner. These fingerprints can produce quantitative maps or synthetic images on a pixel-by-pixel basis, including B0, T2/T2*, and T1 values

This technique has shown potential in mitigating field inhomogeneities in the presence of orthopaedic hardware quantifying cartilage degeneration in osteoarthritis, and measuring skeletal muscle extracellular volume fraction in muscular dystrophy. Motion artifact linked to necessary longer scan times prevents the routine clinical deployment of synthetic MRI and MR fingerprinting procedures acquisition durations.

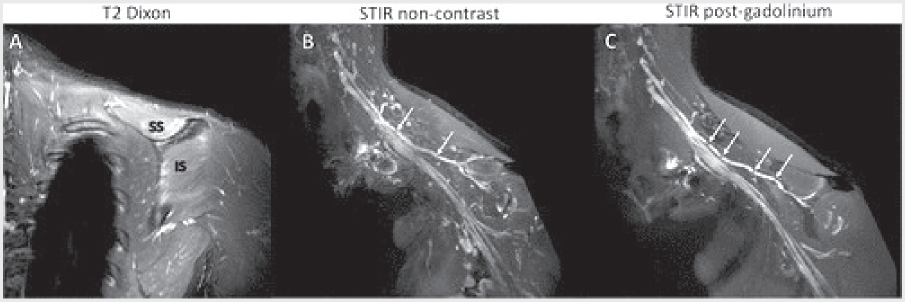
Imaging around Orthopaedic Implants

MRI will probably be utilized more frequently as the number of total joint replacements performed in the US rises to detect issues related to component loosening, such as osteolysis and synovial-based soft-tissue reactions to arthroplasty wear. In the presence of cobalt chromium alloys that impart strong susceptibility effects on surrounding tissues, advanced MRI techniques like 3D multispectral imaging are frequently employed because susceptibility artifact is not routinely mitigated by conventional adjustments (e.g., higher receiver bandwidths, smaller voxels).

Cartilage Imaging

Multiplanar 2D FSE/TSE with intermediate echo durations has been adequately refined during the last 20 years to assess cartilage injury and other joint derangements, both internal and exterior. However, because to fewer partial volume effects, high-through plane 3D scans with multiplanar reformation capabilities may offer better diagnostic performance for cartilage evaluation than several independent 2D acquisitions.

Once the blurring and SNR issues are resolved, we expect that 3D FSE with better through-plane resolution will replace the usage of 2D FSE sequences for cartilage and overall joint evaluation when non-DL and DL acceleration approaches are used.



UTE and Zero-Echo-Time MRI

A highly structured ultrastructure made up of cortical bone, ligaments, tendons, and menisci has very short T2 and T2* values (1 μsec to 11 msec), which causes transverse magnification to fade quickly internetization. Enhancing signal intensity in cortical bone is an instant clinical translation of either ZTE or UTE MRI. UTE and ZTE sequences allow multiplanar reformation, volume rendering, and segmentation tasks, approach the voxel resolution of energy-integrating detector CT, and provide near-isotropic acquisitions in tolerable scanning periods (<7 minutes).

Artificial Intelligence Techniques, including DL

In contrast to traditional reconstruction techniques (such as PI and compressed sensing), which take advantage of data sparsity and coil combinations to shorten acquisition times (usually at the price of signal-to-noise ratio), new AI-based DL algorithms employ various strategies to increase acceleration or enhance image quality. For supervised learning to occur, DL acceleration techniques need a lot of annoyance data and processing power. Convolutional neural networks, which are nonlinear models that derive parameters from the data itself rather than from physics-based equations, are commonly used in these techniques.

Conclusion

Future paths of MRI in relation to musculoskeletal health are difficult to anticipate due to the field's dynamic character. However, across a wide range of magnet strengths, we expect ongoing advancements in field homogeneity and gradient performance in addition to the creation of radiofrequency coils especially made for musculoskeletal MRI exams. Deep learning image reconstruction techniques and acceleration will help optimize three-dimensional acquisitions to increase signal-to-noise ratio and decrease blurring. Because they can simultaneously provide qualitative and quantitative information to describe pathology, synthetic MRI and MR fingerprinting techniques are expected to become more popular. ●

Diffusion-Weighted Imaging and its Advancements

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Diffusion is the random thermal movement of molecules across the membranes. By tracking the motion of the water molecules in a tissue, the mapping of the tissue can be done using the Magnetic resonance phenomenon. The movement of the molecules can be directional or random in all directions.

The diffusion weighting imaging (DWI) technique maps the motion of water molecules at the micro-level, allowing the differentiation of normal and abnormal tissues. DWI considers that water molecules can freely diffuse in any direction i.e., Isotropic diffusion. Since the water diffusion is restricted in abnormal tissues, DWI is widely used in the diagnosis of acute ischemic stroke, brain injury, and inflammations resulting in a reduced apparent diffusion coefficient thus appearing bright in tracer images and darker in ADC maps [Figure 1]. Also, DWI can be used to differentiate malignant from benign lesions, and tumors from edema and infarction since these lesions possess different ADC values.

However, due to the presence of structures such as cell membranes, all the tissues are characterized by anisotropic diffusion. Diffusion Tensor Imaging (DTI) was developed to describe this anisotropic diffusion. Earlier to measure the anisotropic diffusion, the orientation of the axons in a tissue sample has to be known. DTI is an imaging technique in MRI that can be used to depict the orientational features of the diffusion process of water molecules. It allows the investigation of

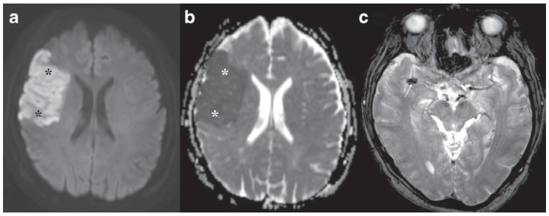

Figure 1: *Acute Stroke – a. Increased signal intensity on DWI which corresponds the area of low ADC value in tracer image and b. darker in ADC map.*

the complicated anatomy of fiber tracts in the human brain by estimating the limited diffusion of water molecules in tissues and generating neural tract pictures.

Diffusion tensor imaging generates multiple parameters like apparent diffusion coefficient (ADC) and fractional anisotropy (FA), which can be used to study the pathological as well as the normal-appearing areas of the brain. This technique is rapidly becoming a standard for the radiological assessment of white matter disorders, as it can reveal abnormalities in white matter fiber structure and provide models of brain connectivity. The application of DTI includes the study of a variety of Congenital neurological defects such as schizophrenia, Alzheimer's disease, autism as well as conditions such as multiple sclerosis, and traumatic brain injury. However, the limitation of the Tensor imaging lies in its inability to demonstrate the diffusion in the crossing of the fiber tracts.

Another application of DWI is Diffusion kurtosis imaging (DKI), an advanced neuroimaging technique that is an extension of diffusion tensor imaging (DTI) by estimating the kurtosis (skewed distribution) of water diffusion based on a probability distribution function. Diffusion kurtosis imaging (DKI) is a dimensionless measure of the deviation of a water diffusion profile from a Gaussian distribution that can be used to estimate excess kurtosis. The evaluation of non-Gaussian diffusion in the brain is a new and promising diffusion technique that can be performed in a clinically feasible time frame, giving us an advantage over the DTI technique. Adding imaging parameters to a traditional diffusion technique, including a minimum of 15 directions and an additional b value, allows measurement of kurtosis as a complement to the traditional DTI dataset. Kurtosis imaging allows for the evaluation of isotropic structures such as the cortex and basal ganglia, which is a major drawback of DTI. DKI can also improve the evaluation of the geometry of crossing fibers for optimizing white matter fiber tracking.DKI and DTI are compared for their efficacy in detecting neural tissue alterations & which demonstrates that DKI offers a more comprehensive approach than DTI in describing the complex water diffusion process. DKI provides independent and complementary information to that acquired with traditional Diffusion sequences. The additional information is thought to indicate the complexity of the microstructural environment of the damaged tissue and lead to broad-reaching application in all aspects of neuroradiology. The major clinical applications of DKI include the detection of Ischemic tissue characterization and Infarction, Neurodegenerative Disease, Demyelinating Diseases by Fiber Tracking, and early Stroke assessment and detection. ●

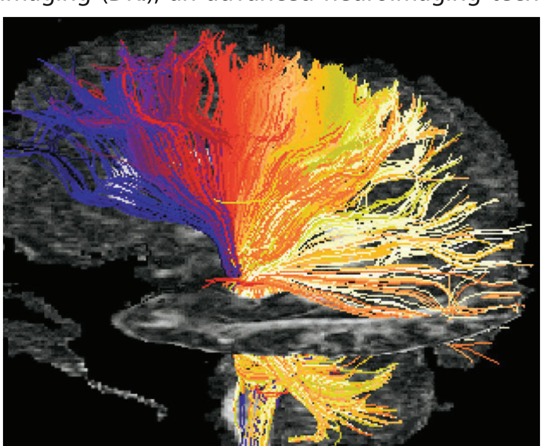

Figure 2: Tractography image of corona radiata

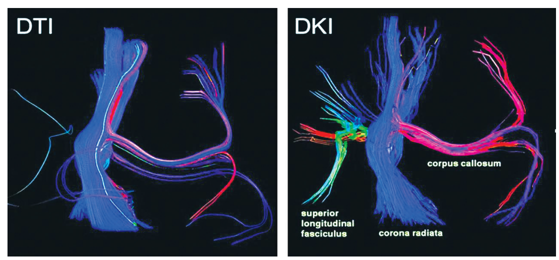

Figure 3: Figure Illustrating the difference in sensitivity of DTI & DKI fiber tracking – better demonstration of crossing fibers in DKI (Image courtesy Paydar A et.al)

Stephen Heilman

Heilman was born on Christmas Day, 1933 in Tarentum, Pennsylvania. Heilman worked as a Commander in the Air Force at the Tactical Air Command Hospital in the Netherlands from 1961 to 1963. In 1964 he founded Medrad Inc, to commercialize an invention he made; it was a device to control the flow of contrast agent during angiography procedures, a flow controlled angiographic injector and pressure tolerant disposable angiographic syringes, advanced the fields of radiology and cardiology by improving the diagnostic image quality and eliminating the imaging risk of blood borne disease transmission from patient to patient. Conceived by physicians Michel Mirowski and Morton Mower, he played a pivotal role in the making of the first automatic implantable defibrillator developed and manufactured under the name of "AID"

105 QUIZ

Compiled by : **Prasad P P**

Abbreviations: Expand the following

1. TACE
2. RFA
3. MRCP
4. SRS
5. MLC
6. SUV
7. LET
8. IGRT
9. PTV
10. EVAR
11. DSA
12. MUGA
13. DEXA
14. DICOM
15. IMRT
16. DVT
17. PET
18. PACS
19. TRUS
20. CTPA

Please mail your answers and contact number to **alaraquiz@isrt.org.in** before **15th APRIL 2025**, The subject of mail should be given as **ALARA Q-105**

Answer Key Q-104

1. Sievert
2. Reasonably
3. Decontamination
4. Inverse Square Law
5. 0.25mm
6. 20 mSv
7. One
8. 0.02mSv
9. Lead
10. Gamma radiation
11. Coulombs/Kg (Roentgen)
12. Stochastic effect
13. Linear Energy Transfer
14. Scattered radiation
15. Bremsstrahlung radiation

Winner : Anto Maneesh , Vijayawada, AP

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Indian society of Radiographers' and Technologists congratulates the newly appointed members of Medical Radiology Imaging and Therapeutic Technology Professional Council in National Commission constituted under NCAHP ACT2021. Formation of separate professional council and appointment of members with outstanding academic and professional leadership will make revolutionary changes in the Radiological Technology profession in India. The same will explore endless opportunities of development pertaining to Radiology Technology profession with a regulatory control over the professional practice and education in our country.

In Loving Memory of

Mr. Chinmoy Das

Assistant Professor, Programme of Radiology and Advanced Imaging Technology
Faculty of Paramedical Sciences, AdtU

With profound sadness, we mourn the passing of Mr Chinmoy Das, Assistant Professor, Programme of Radiology and Advanced Imaging Technology, Faculty of Paramedical Sciences, Assam down town university. A dedicated educator and a guiding light to many, his contributions to the academic and professional growth of his students will always be cherished. Our thoughts and prayers are with his family friends, colleagues and students in this difficult time. May his soul rest in eternal peace.

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