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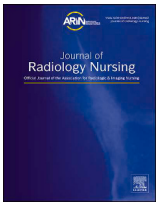

Research Paper

MRI Safety in Indian Clinical Practice: A National Survey of Radiographers

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A B S T R A C T

Background: Magnetic resonance imaging (MRI) has a high quality of images but does not use ionizing radiation; however, it poses a strong safety concern. Radiographers are required to follow high standards because of threats posed by magnetic fields and radiofrequency energy. This paper analyzes the MRI safety practices of Indian radiographers.
Methods: It is a cross-sectional survey, and therefore, it examines the state of MRI safety practices used by radiographers in India. Two hundred and three respondents completed online structured questionnaires on the zoning system, patient screening, consent, emergency preparedness, and the knowledge of MRI hazards.
Results: Radiographers showed great theoretical understanding of MRI safety, but it was not well implemented in practice. Some of the main gaps were the lack of metal detectors utilization, emergency readiness, and infrequent safety drills. Such gaps indicate the necessity of the country's level of safety standards and organized training.
Conclusion: The research demonstrates that there is a high level of theoretical awareness of MRI safety among radiographers. However, it is ad hoc, and the issues reported include the incompatibility of emergency equipment, safety drills, and the presence of metal detecting tools. These lapses in the safety procedure simply lend credence to the immediate necessity to develop a set of national standards on MRI safety, which makes it mandatory as training on safety, as well as regular audits. Compliance to this will not only enhance safety of the patients but also will entrench the safety of the radiology personnel and enhance clinical outcomes in MRI practice across India.

Introduction

Magnetic resonance imaging (MRI) is a noninvasive modality for imaging used widely for tackling diverse medical conditions. MRI serves to produce high-resolution, multi-planar anatomical images as well as functional images, with no ionizing radiation involved; thus, from a safety perspective, MRI enjoys preference over other conventional modalities of imaging such as the computed tomography scan or X-ray (Hartwig et al., 2009). MRI is based on the principle that hydrogen nuclei in the body align under a very strong, static magnetic field. When disrupted by radiofrequency (RF) pulses, these nuclei produce signal emissions which are then used, with the help of time-varying gradient fields, to produce finely detailed images (Panych & Madore, 2018).

MRI is applicable in varied clinical disciplines. It forms the backbone of neurology, providing brain imaging of detail for tumors, multiple sclerosis, and vascular anomalies, among others. It is the second most important imaging method after roentgenography for the evaluation of soft tissues of ligaments, cartilages, and tendons in orthopedics. It is also very important in oncology for the purpose of tumor characterization, staging, and assessment of response to therapy. Cardiovascular MRI enables cardiac anatomy, function, perfusion, and viability to be visualized without contrast agents in some sequences. Functional MRI is used for neuroscientific research to map brain activity underlying cognitive processes (Opoku et al., 2013).

MRI is employed in preoperative and postoperative follow-up, as well as image-guided interventions. Hence, it is an

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indispensable element of modern medicine. And with the appearance of more advanced techniques such as diffusion-weighted imaging, perfusion imaging, magnetic resonance spectroscopy, and real-time MRI, the applications have become even more widespread in both the clinical and research domains (Weidman et al., 2015).

When confronted with the advantages of MRI, one must also examine its disadvantages. It presents safety complications relative to the ferromagnetic materials, implants, and emergencies, owing to the presence of a strong static magnetic field and the application of RF energy. These factors necessitate strict adherence to safety procedures from all who work in the MRI field, such as radiographers, who are key players in MRI operation (De Wilde et al., 2007; Kanal et al., 2007; McRobbie, 2020; Shellock & Crues, 2004).

The presence of implanted medical devices is a serious hazard in MRI. Some devices like pacemakers, neurostimulators, cochlear implants, or metal prostheses may malfunction, migrate, or overheat under strong magnetic forces, creating a life-threading situation for the patient (Mittendorff et al., 2022). To minimize such dangers, the notion of MRI device safety labeling has evolved with the accommodation of manufacturers' testing and guidelines into three different classes: magnetic resonance (MR) Safe, MR Conditional, and MR Unsafe (Panych & Madore, 2018).

The study examines the awareness and realization of MRI safety among radiographers in India, a country rapidly growing in MRI adoption. It highlights the extent to which safety protocols are followed in clinical practice and pinpoint areas that require improvement—with the goal of closing the gap between theory and implementation (Bottomley, 2008).

- An MR Safe device is known to pose truly no hazards in all MRI environments and is made of only nonconducting/nonmetallic/nonmagnetic materials.
- MR Conditional devices are only able to be scanned if certain conditions related to static magnetic field strength, spatial gradients, and RF exposure limits are fulfilled. These conditions must be faithfully adjoined, often requiring custom scanning protocols.
- MR Unsafe devices are known hazards and are contraindicated in the MRI environment.

In order to avoid any hazards, several professional organizations like the American College of Radiology have developed general safety criteria, including a zoning system based on magnet proximity (Zones I-IV); strict screening of patients for contraindications, including implants and metallic fragments; proper warning signs about magnetic hazards; and the use of only MR-safe or MR-conditional emergency equipment within the MRI suite (Kanal et al., 2013). Other clinical academia automatically verifies implant condition via manufacturer documentation or an online database (e.g., MRIsafety.com) to ensure safety for all patients.

The purpose of this research is to determine the level of knowledge, awareness, and implementation of MRI safety practices among radiographers in India. It mainly focuses on evaluating adherence to essential safety procedures, such as zoning, patient screening, patient consent, emergency preparedness, and the use of MR-compatible instrumentation. This would help in determining evidence-based changes in national MRI safety guidelines and training.

Methods

Study Design

The study design was descriptive cross-sectional survey design that sought to assess the MRI safety practices of radiographers in India.

Research Environment

The study was conducted in various health-care facilities in India that offer services of MRI, and they included the government hospitals, the private hospitals, the educational institutions and the diagnostic centers.

Population and Sample

The target population included MRI technologists and radiographers who are either in service or training MRI in India. Then, 203 respondents were taken as the final sample that was computed by use of the Raosoft, sample size calculator, with the confidence level of 95%, 5% margin of error, and the distribution of the responses assumed to be 50%.

Sampling Method

Convenience sampling was adopted in which all the participants were given an opportunity to join by sending questionnaires online.

Data Collection Tool

A structured Google form consisting of 25 close-ended questions was used to collect the data and was divided into seven parts including demographics, zoning system and signage, patient consent practices, screening protocols, awareness of MRI-related hazards, emergency preparedness and perceived barriers to keeping MRI safe. Questionnaire validity was also guaranteed, through pilot study conducted on a sample population consisting of radiographers and through some addendums made with the assistance of the experts to enhance clarity, relevance and reliability of the instrument.

Ethical Approval

This study received ethical clearance from the *Institutional Ethics Committee, CHARUSAT University*, under Approval ID IEC/CHARUSAT/EX/24/274. The committee granted an exemption from full committee review, as the research involved no direct interaction with participants and utilized an anonymous online questionnaire.

Inclusion Criteria

MRI technologists working in public/private hospitals or diagnostic centers across India, and those who consented to participate.

Exclusion Criteria

Individuals not working with MRI and those who declined consent were excluded.

Informed Consent Statement

Participants were informed about the purpose, procedures, and voluntary nature of the study. They were informed that they could withdraw at any time without consequences. Submission of the online questionnaire was taken as implied consent. Confidentiality and anonymity were maintained, and no personal identifiers were collected.

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Results

Demographic Distribution

Most of the respondents involved in this research were between the ages of 22 and 30 years and had a degree in radiography. Most of them were full-time MRI technologists who were employed at clinical practices. The wide geographical coverage was realized and the radiographers in North, South, and Northeast India participated. It is worth noting that a huge percent of the sample had less than 5 years' experience, which reflects a young and rather early career workforce. This population characterizes the present generation of MRI technologists in India and gives an idea of the present training and awareness environment.

Awareness and implementation of safety zones

Question	Yes (%)	No (%)
Familiarity with zoning system	88.4	11.6
Implementation of zoning system	85.7	14.3
Restricted access to zone III	76.3	23.7

Interpretation

- The awareness of the theoretical knowledge of zoning systems was wide since a statistically significant proportion of radiographers stated they were familiar with this system and used it.
- The limited access granted to Zone III was less than the overall rate of awareness and implementation (and thus less than the one that could be viewed as optimal) but still statistically significant, $p = .002$, pointing to a necessity of putting even tighter measures to control them in some of the facilities.

Consent and screening procedures

Procedure	Practiced (%)
Mandatory written consent	93.2
Verbal cross-check of consent	89.4
Screening for implants/metal	95.1
Use of hand-held metal detector	11.2

Interpretation and Observations

- Many of the radiographers (93.2%) were found to ask written permission, and it is an indication that they are highly compliant to both legal and ethical practices before carrying out MRI.
- Verbal cross-checking of consent is practically used by all radiographers (89.4%), which is a very good practice to make sure that patients have been informed and have reassessed their knowledge before going through with the scan.
- The response rate of implant and other metallic foreign body screening was found to be 95.1%, which shows that the participants were aware of the significant risks of implants in an MRI setting.
- On the contrary, however, small 11.2% indicated that a hand-held metal detector was employed in the screening process, which shows a significant gap in the application of technological overheads that are capable of significantly complementing patient safety by tracing items missed during the manual process. This may also give an indication that such devices are just not there, or it is not used due to workflow reasons.
- Therefore, such results show that radiographers use manual screening like verbal and written screening and the employment of the additional technologies like metal detectors is fundamentally not yet adopted as a best practice, which is a significant oversight in best safety practice.

Knowledge of hazards and preparedness

Item	Awareness (%)
Static field biological effects	91.3
Specific absorption rate (SAR) limits	84.5
Peripheral nerve stimulation risks	78.6
Emergency communication system	69.7
MR-safe emergency equipment available	51.8
Participation in safety drills	38.2

Interpretation and Observations

- Theoretical knowledge appeared to be in 91.3% of the respondents as pertained to the element of the static-field biological effects, which implies that they have understood how the nonstatic magnetic field may have any interaction with the biological tissues as well as the ferromagnetic materials.
- Specific absorption rate awareness (84.5) demonstrates that most radiographers recognize the importance of regulating the amount of RF energy deposited to prevent thermal injuries; nevertheless, some of them still have the knowledge gap.
- Peripheral nerve stimulation was classified as a risk by 78.6% of the respondents, which is a reasonably good insight that still room fades away as practical uses where patient feedback is a commonly relevant concern.
- Awareness of emergency communication systems in MRI suites was only 69.7, which concerned the emergency preparedness during anointed activation like quenching or patient distress.
- The reported awareness level about MR-safe emergency equipment was 51.8%, and it indicates a severe issue about being prepared to face an emergency. Failure to have proper availability or awareness of MR-conditional or MR-safe instruments in an emergency would result in a grossly life-threatening delay or error.
- What is more distressing than alarming is the rates of safety drills of attendance with only 38.2% of them having attended to anyone, disclosing very low involvement in practical training and implementation of established safety measures. Failing to perform drills on a regular basis is an act, which compromises preparedness further when there are conditions of high risks.
- These results hint at the fact that whereas the converse may be stated related to radiographic staff on the aspect of having substantial theoretical understanding with regards to the issue of MRI hazards, there is an observable void in the operationally oriented side of the primarily emergency interventions, which could be addressed by the means of structured training, simulations, and audits conducted periodically. Figure 1 illustrates the awareness of MRI-related

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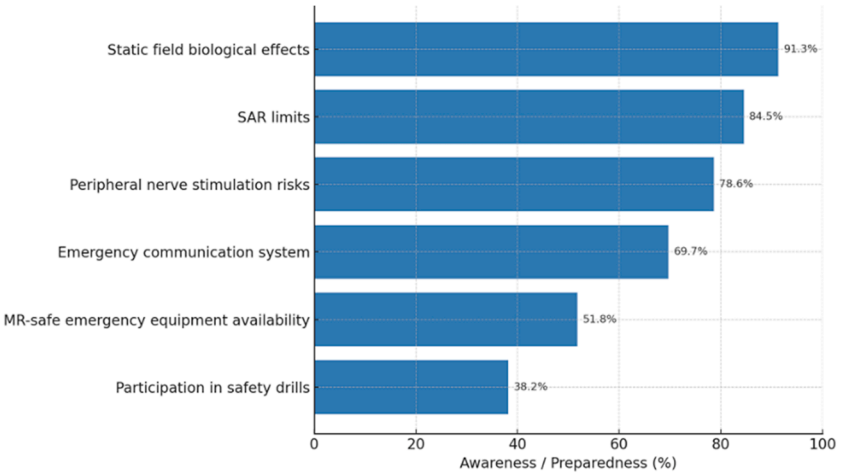

Figure 1. Awareness and emergency preparedness among radiographers.

Table 1
Summary of key findings and comparative implications from discussion

Key aspect	Findings (India)	Comparative findings	Implications
Theoretical awareness	High awareness of zoning, screening, and hazard identification among radiographers	Similar theoretical awareness reported in Greece (Stogiannos & Westbrook, 2020) and Jordan (Ayasrah, 2020)	Indicates strong foundational knowledge; theoretical training is effective across countries
Practical implementation	Inconsistent application of protocols; ad hoc implementation in many centers	Comparable inconsistencies noted in Greece and Jordan despite adequate knowledge	Reveals a knowledge-to-practice gap; calls for stronger procedural enforcement
Emergency preparedness	Rare safety drills; limited availability of MR-compatible emergency equipment	Studies from Saudi Arabia and Bangladesh also highlight limited emergency preparedness (Alghamdi et al., 2022; Hossen et al., 2020)	Limits emergency responsiveness; increases risk of harm to patients and staff
Metal detection	Only 11.2% used hand-held detectors for metal screening	Similar underutilization reported in Jordan and Ghana	Increased risk of accidents from unnoticed metallic objects; investment in screening tools needed
Geographic disparity	Urban and academic centers showed better safety adherence than rural/independent setups	Geographic and institutional disparities also observed in Greece and Bangladesh	Unequal access to training and equipment; need for equity-focused safety implementation
International comparison	Mirrors global pattern: high awareness not translating into practice	Greece, Jordan, and others confirm the same mismatch between safety knowledge and implementation	Highlights the universal challenge; localized interventions and follow-up audits required
Need for national guidelines	Absence of national MRI safety policies and standard operating procedures	ACR guidelines exist in the United States, but many developing countries report similar policy gaps	Centralized guidelines and legal enforcement are urgently needed in India
Training and oversight	Lack of regular safety training, recertification, and institutional audits	Recurrent issue in global studies—training is inconsistent and often one-time	Structured, recurring training and compliance audits are necessary for sustainable improvement

ACR = American College of Radiology; MRI = magnetic resonance imaging.

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hazards and emergency preparedness among the surveyed radiographers.

Challenge identified	Observation
Lack of standard safety protocols	Participants reported inconsistency in safety procedures across institutions.
Limited training opportunities	Many respondents expressed a need for regular, structured training sessions.
Unavailability of MR-safe equipment	Several noted the absence of MR-compatible tools during emergencies.
Weak regulatory enforcement	There were concerns about the lack of audits and national safety enforcement.

Key Observations From Open Responses

The unsystematic responses reflected the issues of systems-wide problems that affect the safety of MRI. A frequent theme was the lack of standardization of safety processes and in one institution, it was very different in another. One of the most significant barriers was identified as the lack of training opportunities, especially in case with the technologists of rural or under-resourced centers. Furthermore, inadequate access to MR-safe emergency gear turned into an existential problem since it limits the response to an incident to do it safely. Finally, as the reasons why noncompliance is not punished, poor regulatory control and absence of regular safety inspections were mentioned. All these results prove that there is a necessity to create a single and national policy concerning the MRI safety standards in India.

Discussion

The study reveals that there is a considerable gap between the theory of MRI safety and the clinical practice among the radiographers in India. Though, most of the respondents were allegedly aware of the theoretical knowledge of zoning systems, patient screening, and potential harm of MRI, the working standards as safety measures and processes were inconsistent. One of the most stable weaknesses was the practical sphere of the adequate provision and utilization of MR-safe emergency equipment because, as it can be seen, this kind of drills is hardly conducted. These constitute the necessary measures that must be provided to deal with any emergency cases such as ferromagnetic projectiles or equipment quenching and in which absence of such facilities may lead to disastrous effects on the safety of the patients and the staff. A summary of the key findings of the present study in comparison with international evidence and their implications is presented in Table 1.

Besides this, the findings show that metal detectors, such as hand-held metal detectors or ferromagnetic metal detectors, are not frequently used, and this has a high chance of accidents. The findings of the international literature in the same way, such as that conducted by Stogiannos and Westbrook, (2020) in Ayasrah (2020) in the rest of Jordan, confirm that the same trend of high awareness rate and poor implementation was noted.

In addition, it is found that the radiographers in urban and well-equipped or academic hospitals put safety provisions than the region or stand-alone facilities. This implies that training, infrastructural, and institutional support have inequalities that are required to provide safe MRI practice.

Thus, the Indian radiographers see the necessity of the final significance of the MRI safety; however, the practical differences are found between the knowledge translation and the practical execution of the safety measures by the radiographers. Nationwide and standard policies and programs of training of MRI safety are thus immediately required to control application. These gaps will be eradicated, which will ensure the improvement of the optimal safety, risk avoidance, and homogeneity of practice witnessed in all healing settings.

Limitations

This study is deficient in various ways. First, generalizability of the findings is at risk since one can use convenience sampling hence the sample may not be representative of the whole population of MRI technologists in India. Self-reported information is supported with a possibility of possible response bias or compliance exaggeration. The fact that the questionnaire was online could have eliminated some of the participants who could not use the internet or were not tech savvy. The cross-sectional design, its turn, provides an image of the practices, and there is no way to assess the shift in the MRI safety practices across time and when some interventions might have helped the improvement of the said practices.

Future Scope

The given study may be regarded as a base of acquiring knowledge about the MRI safety practice of radiographers in India and has countless possibilities in generating research and defining a policy. This will provide the researchers with a chance to conduct a longitudinal study in which the effectiveness of the safety training intervention and improvements concerning the same would be assessed with time. A larger sample and more heterogeneous health-care facilities, especially rural and less resource-endowed ones, would provide a rather more concrete national perspective. Furthermore, more information about institutional barriers and barriers to compliance can be unwound by a qualitative study in the form of interviews or focus group discussions of MRI technologists, administrators, and policymakers. The development of a generic national MRI safety framework and the standard certification and recertification systems will also be an important factor in enhancing the standards of safety. The regulating bodies, academic and health-care institutions, and health-care providers must also work together in developing standards that are peculiar to the Indian health-care setting. The development of a bridge between awareness and systematic and effective practice in the MRI facilities across the country will need a long-term research and policy initiative.

Conclusion

This study revealed that the theoretical understanding of Indian radiographers about MRI safety measures particularly the zoning, screening and identifying hazards is very high, however, there is discrepancy in the real performance. The primary safety failures that have been identified included emergency preparedness: the lack of antipersonnel MR-safe equipment and low participation in safety exercises. It was found that the respondents who were in urban centers and academic centers were more inclined to take safety measures in comparison to the respondents who were in rural centers or the personal institutions. It is here that an MRI safety guideline on national standards, frequently recurrent training and monitoring mechanisms is desperately required, in order that the difference in understanding and practice may be tightened, and a more secure MRI atmosphere ensured to the patient and the worker.

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Conflict of interest

The author(s) have no relevant disclosures. There was no grant funding or financial support for this manuscript.

Patient consent/ethics statement

This study received ethical approval from the Institutional Ethics Committee (IEC), CHARUSAT University (Approval No.: IEC/CHARUSAT/EX/24/274). The study involved an anonymous online questionnaire and no direct interaction with participants. Participation was voluntary, confidentiality was maintained, and no personal identifiers were collected. Completion and submission of the questionnaire were considered as implied informed consent.

CRediT authorship contribution statement

Sapna Bhatt: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Mamta Panda:** Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Santosh Ojha:** Writing – review & editing, Software, Resources, Methodology. **Lalit Kumar Gupta:** Visualization, Validation, Supervision.

References

Alghamdi, N., Alqahtani, A., Alshahrani, A., & Alharthi, M. (2022). A national survey on MRI safety practices in Saudi Arabia. *International Journal of Health Sciences, 16*(5), 15-25.

Ayasrah, M. (2020). MRI safety practice observations in MRI facilities within the Kingdom of Jordan, compared to the 2020 American College of Radiology (ACR) MR Safety, Manual. *Journal of Radiological Safety and Practice, 8*(3), 112-119.

Bottomley, P.A. (2008). Turning up the heat on MRI. *Journal of the American College of Radiology, 5*(7), 853-855.

De Wilde, J.P., Grainger, D., Price, D.L., & Renaud, C. (2007). Magnetic resonance imaging safety issues including an analysis of recorded incidents within the UK. *Progress in Nuclear Magnetic Resonance Spectroscopy, 51*(1), 37-48.

Hartwig, V., Giovannetti, G., Vanello, N., Lombardi, M., Landini, L., & Simi, S. (2009). Biological effects and safety in magnetic resonance imaging: A review. *International Journal of Environmental Research and Public Health, 6*(6), 1778-1798.

Hossen, M., Rana, S., Parvin, T., Muraduzzaman, S.M., & Ahmed, M. (2020). Evaluation of knowledge, awareness, and attitude of MRI technologists towards MRI safety in Dhaka city of Bangladesh. *Hospital, 20*, 40-45.

Kanal, E., Barkovich, A.J., Bell, C., Borgstede, J.P., Bradley, W.G., Froelich, J.W., et al. (2013). ACR guidance document on MR safe practices: 2013. *Journal of Magnetic Resonance Imaging, 37*(3), 501-530.

Kanal, E., Borgstede, J.P., Barkovich, A.J., Bell, C., Bradley, W.G., Felmlee, J.P., et al. (2007). American College of Radiology white paper on MR safety. *AJR American Journal of Roentgenology, 188*(6), 1447-1474.

McRobbie, D.W. (2020). *Essentials of MRI safety*. Oxford, UK: John Wiley & Sons.

Mittendorff, L., Young, A., & Sim, J. (2022). A narrative review of current and emerging MRI safety issues: What every MRI technologist needs to know. *Journal of Medical Radiation Sciences, 69*(2), 250-260.

Opoku, S., Antwi, W., & Sarblah, S.R. (2013). Assessment of safety standards of magnetic resonance imaging at the Korle Bu Teaching Hospital (KBTH) in Accra, Ghana. In *Imaging and Radioanalytical Techniques in Interdisciplinary Research* (pp. 35-42). Berlin, German: Springer.

Panych, L.P., & Madore, B. (2018). The physics of MRI safety. *Journal of Magnetic Resonance Imaging, 47*(1), 28-43.

Shellock, F.G., & Crues, J.V. (2004). MR procedures: Biologic effects, safety, and patient care. *Radiology, 232*(3), 635-652.

Stogiannos, N., & Westbrook, C. (2020). Investigating MRI safety practices in Greece: A national survey. *Hellenic Journal of Radiology, 5*(2), 24-35.

Weidman, E.K., Dean, K.E., Rivera, W., Loftus, M.L., Stokes, T.W., & Min, R.J. (2015). MRI safety: A report of current practice and advancements in patient preparation and screening. *Clinical Imaging, 39*(6), 935-937.

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