IPEM

Institute of Physics and Engineering in Medicine
01904 610821
office@ipem.ac.uk

Fairmount House
230 Tadcaster Road
York YO24 1ES

ipem.ac.uk

Policy Statement

The role of the Clinical Scientist in Magnetic Resonance Imaging

Angela Darekar, Michael Hutton, Lucy E Kershaw, John McLean and Rebecca Quest (2022).

Executive Summary

This policy statement sets out the role of the clinical scientist working within Magnetic Resonance Imaging (MRI). The intended audience of this policy statement includes clinical scientists working in MRI and those in senior management roles, both within medical physics departments and the wider healthcare system (for example radiology service managers). The policy statement focuses on key elements of the role where MR clinical scientists contribute to the safe, effective and efficient delivery of high-quality MRI services. MR clinical scientists are also important for improving and developing MRI services and such roles require both senior leadership within MR physics departments and sufficient scientific staffing levels. We highly recommend that senior healthcare management engage with their medical physics leadership team and consult the IPEM ratified workforce planning assessment tool to capture and estimate their MR clinical scientist workforce requirements [1].

The MR Special Interest Group have also prepared a policy statement regarding scientific safety advice to MRI units and the role of Magnetic Resonance Safety Experts, 'Scientific Safety Advice to Magnetic Resonance Imaging Units that Undertake Human Imaging' (2023) available via the IPEM website.

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Introduction

Magnetic Resonance Imaging is a highly complex non-invasive imaging modality that delivers detailed anatomical and functional images for diagnosis, treatment planning and research. This technology requires high-level scientific and safety support for its safe and effective use. This policy statement is issued by the Institute of Physics and Engineering in Medicine (IPEM) to define the activities performed by MR clinical scientists and is in accordance with the MHRA guidelines [2].

Healthcare Scientists in Magnetic Resonance

Healthcare scientists play a vital role in the prevention, diagnosis and treatment of medical conditions, using scientific knowledge and technical skills to improve patient care. Magnetic Resonance comes under the medical physics subdivision of physical sciences, one of the main areas of practice of healthcare scientists.

Clinical Scientists in Magnetic Resonance

The term 'clinical scientist' is a legally protected title for healthcare scientists who have completed sufficient training to become statutory regulated healthcare professionals and have attained registration with the Health and Care Professions Council (HCPC) [3]. MR clinical scientists require the theoretical knowledge and practical skills to perform an essential role within a multidisciplinary team delivering an MRI service. MR clinical scientists have an appropriate undergraduate degree with honours in a science containing a high level of physics, plus a combination of relevant postgraduate learning (MSc or PhD) and vocational training. This can be achieved through the NHS Scientist Training Programme (STP) [4] or equivalence routes.

Magnetic Resonance Safety Expert

A Magnetic Resonance Safety Expert (MRSE) is typically an MR clinical scientist with a thorough and detailed understanding of MR physics with appropriate skills, knowledge and experience of MR imaging equipment. The certification model adopted by IPEM [5] requires demonstration of both knowledge and experience. Knowledge is demonstrated by passing the American Board of Magnetic Resonance Safety (ABMRS) MRSE exam, while experience is assessed by IPEM via a structured portfolio of MRSE activities. For more information on the MRSE role and scientific support to MR units, see the IPEM position statement on Scientific Safety Advice to MR Units that Undertake Human Imaging [6].

Scientific Services in MRI

The input of an MR clinical scientist will greatly enhance both the safety and the efficiency of the MR service. The role of the MR clinical scientist includes:

- Safety
- Quality Assurance and troubleshooting
- Procurement and site design
- Clinical service delivery and improvement
- Quality management and governance
- Research development and innovation
- Education and training
- Clinical scientific computing and informatics

Safety

MRI is a non-ionising radiation technique, unlike x-ray and radioisotope imaging, and is considered safer as a result. However, MRI poses unique and acute safety risks due to its use of an extremely strong static magnetic field, rapidly time-varying magnetic field gradients, radiofrequency transmission, high acoustic noise levels, and cryogenic liquids. There have been several fatalities and serious injuries related to MRI [7] [8] [9] [10] [11] [12] [13]. Many other adverse events can occur in MRI, the vast majority of which are avoidable through having well-designed MR units, ongoing safety training and expert support from an MR clinical scientist. The MR clinical scientist has a crucial role in helping to ensure that safety is maintained for all patients, staff and visitors and that appropriate risk assessments, policies and standard operating procedures are in place and kept up to date with legislation, guidelines and recommendations [2] [14] [15] [16] [17].

MR clinical scientists lead on the development of MR local rules and MR safety frameworks as well as procedural development, such as protocols for the use of MR Conditional items within the unit. MR clinical scientists maintain an up-to-date knowledge of relevant scientific, technological and regulatory developments and where appropriate, they lead on changes in local practice. The MR clinical scientist is an integral part of the local MR safety committee and may lead this group. The MHRA recommends that new staff receive MR safety training and that regular updates are provided to existing staff. The MR clinical scientist typically oversees this training. MR clinical scientists are also involved in investigating and reporting MR safety incidents [18], which may include reviewing the specific circumstances, educating staff on the cause of an incident and implementing methods to reduce the likelihood of recurrence.

Patients with passive and active implanted medical devices are regularly referred for MRI. MR clinical scientists advise on the risks posed by the interaction of these devices with the electromagnetic fields associated with MRI, as well as implementing methods to minimise risk. In many instances, this requires a high level of expertise and an awareness of developments in implant technology and the implications of scanning a patient using a particular MRI system. An MR clinical scientist may perform risk *vs* benefit assessments to facilitate scans for patients who would otherwise be denied MRI, for example where complete implant information is unavailable or for MR Unlabelled CIEDs (cardiac implanted electronic devices) [19]. In addition, an MR clinical scientist can implement processes to conduct formal safety testing of equipment and implants in accordance with international standards [20] [21] [22] [23] [24].

Quality Assurance and Troubleshooting

Following the manufacturer's commissioning of a newly installed MR system, acceptance testing should be performed by an MR clinical scientist. The acceptance test should establish whether the system is suitable for introduction into clinical use and facilitates system benchmarking. The acceptance test should also include a safety review of the MR unit and a static magnetic field survey.

It is important that the images and data produced by an MR system are accurate, reliable, representative of the patient and of diagnostic quality. An appropriate Quality Assurance (QA) program should be adopted to ensure that the MRI system continues to meet a standard for clinical use through system performance monitoring, audit, review and any necessary corrective action [2] [25] [26] [27] [28] [29] [30]. MR clinical scientists are also regularly involved in troubleshooting image artefacts and system errors and determining the root cause of scan failures and system downtime.

Managing the equipment lifecycle

As a greater number of NHS Trusts and Health Boards move towards the adoption of a Managed Equipment Service (MES) to coordinate and manage their radiology technical infrastructure, it is important to engage with an MR clinical scientist at every stage of this partnership to ensure safety, quality and value for money. This may include horizon scanning to inform strategic decision making relating to new equipment, developing contract specifications, assessing the resulting bids from MES provider and contributing to business cases for service expansion and equipment replacement. There are further requirements to liaise closely with the MES provider to carry out initial fault finding to ensure continuity of the clinical service, to assess scanner downtime and MES service performance and generally provide the scientific support described below, in partnership with these companies. There may be discussions about research and development provision and how this works within an MES contract, or input into other innovation collaborations with MES providers.

Installation of MR systems can require design of new buildings, extensive modification of existing buildings or upgrading of existing departments. An MR clinical scientist is a vital stakeholder in all installation projects and should be involved at the earliest discussions, from the feasibility stage. Included in the project team, MR clinical scientists will work in collaboration with project managers, the MR manufacturer, architects, estates departments and clinical staff to review practical considerations of the MR suite layout in order to facilitate safe and efficient throughput of patients. During the design process, the MR clinical scientist's knowledge of MR systems and MR safety enables the project team to ensure that key considerations are taken into account for the subsequent safety and management of the MR unit and to mitigate risk. An MR clinical scientist advises on facility layout, patient access pathways, cryogen venting, safety of people around the department and the mutual impact of the MR system and the surrounding environment. National and international guidance documents recommend the inclusion of an MRSE and/or MR clinical scientist on the design team [2] [15] [16] [17] [31].

When procuring new or upgraded MR equipment, it is vital that appropriate technical performance criteria are formally specified with input from a MR clinical scientist in order to meet the diagnostic clinical service and research needs. This is essential as there is a wide range of commercially available MR equipment and consideration must be given to intended function and required level of performance while achieving value for money. It is strongly recommended that an MR clinical scientist is involved in assessing complex procurement responses and informing decisions regarding gradient specification, coils, pulse sequences and image post-processing. The MHRA [2], EFOMP [15] and ACR [17] all recommend the inclusion of an MR clinical scientist and/or MRSE on the procurement project team. These same recommendations apply to MR hybrid systems, working alongside other clinical scientists.

Ancillary equipment such as power injectors, ventilators and monitoring equipment are often used within the MR scanner room, for example to support the scanning of patients under general anaesthetic. In addition, other equipment such as that used for fMRI/EEG-fMRI (functional MRI/electroencephalogram-fMRI) or interventional/intra-operative MR requires scientific support. MR clinical scientists are involved in the safety testing, procurement and labelling of appropriate ancillary equipment to support these activities, determining potential risks and developing effective management controls for their safe use. MR clinical scientists can also be involved in the procurement, design and safety testing of bespoke equipment and test objects, ensuring it is safe and functioning properly, and does not interfere with the MR scanner [32].

Decommissioning of MR scanners may benefit from MR clinical scientist advice in regard to safe and effective removal of equipment. This may require liaising with manufacturers or third-party companies who specialise in the equipment removal, which may be necessary to ensure the equipment can be repurposed.

Clinical service delivery and improvement

MRI continues to see notable advances in hardware, pulse sequences, image reconstruction and image analysis. MR clinical scientists can lead on and assist with the process of establishing new technologies through appraisal of the literature and the market place, planning services and preparing business cases. MR clinical scientists also play a key role in implementing these new technologies and techniques to improve the quality and efficiency of the patient care pathway.

There is an ongoing requirement to establish optimal sequences for clinical applications, tailored to the anatomy, pathophysiology and biochemistry of disease. This requires an understanding of MR physics, sequence implementation and the clinical condition under assessment. Anatomical and physiological information may be missed if the wrong pulse sequence is used. MR clinical scientists work with radiologists, referring clinicians, radiographers and manufacturer application specialists to optimise existing techniques, for example, to achieve a balance between acceptable image quality and acquisition time.

Image analysis can enhance and quantify the clinical information from patient MR images. MR clinical scientists have a role in assessing, validating, implementing, and sometimes creating new analysis techniques and software. They are further involved with the implementation of these techniques for individual patient care which may also include contributing to clinical reporting or to multidisciplinary teams.

Quality Management & Governance

The responsibility of ensuring good governance typically falls to the lead MR clinical scientist. However, all MR clinical scientists play an important role in driving and contributing to this. Ensuring good governance requires systems be put in place to manage policies and procedures, whilst also ensuring that lines of communication, reporting and decision making within and between organisations exist and function effectively. Consideration of governance is particularly important when organisations are changing processes and developing new services. Specific areas of governance relevant to the role of an MR clinical scientist include safety and clinical auditing, equipment management including QA, implementation of new protocols and procedures, software management and research governance.

It is the role of a MR clinical scientist to adhere to risk and quality management principles. For example, MR physics services may operate within a department's quality management system (QMS), such as accreditation to the ISO9001 (2015) standard [33]. Key processes and services should be provided in a robust and sustainable way, and developed to suit the needs of stakeholders, whether that be radiology departments, patients, or researchers. MR clinical scientists may also be involved in supporting radiology departments to gain QSI (Quality Standards in Imaging) accreditation [34], covering domains such as staffing, training, MR safety procedures, record keeping, clinical pathways and clinical audit.

Research, Development and Innovation

MR is a rapidly developing field and MR clinical scientists require an understanding and awareness of cutting-edge techniques and technological advances. MR clinical scientists often have strong links with academic units, clinical trial units or industry (sometimes as joint appointments), and are ideally placed to translate research, development and innovation into clinical practice, to drive change as a key member of a multidisciplinary team.

MR clinical scientists can be involved at every stage of a research project, leading, or supporting experimental design, protocol development and validation, governance, data management and image and statistical analysis through to the presentation and publication of results. They may be principal investigators, obtaining grants and leading research projects themselves.

MR is also extensively used as a research tool in clinical trials. MR clinical scientist involvement is important in collaborative, often multicentre, research projects. They can provide vital MR physics expertise as part of the research delivery team; or provide safety, regulatory and governance support.

Education and Training

MR clinical scientists contribute to the continuous professional and personal development of many staff groups. They are extensively involved in teaching MR physics and clinical applications, and delivering safety training to a wide range of healthcare professionals and other staff groups (e.g. radiographers, radiologists, clinicians, researchers, domestic staff). Education and training are provided on the science underpinning MR and also on practical aspects such as image optimisation and protocol development, thereby enhancing the safety, quality and efficiency of the MR service.

MR clinical scientists are widely involved in educating and supervising trainee clinical scientists as part of the National School of Healthcare Science [4] [34]. They contribute to the NHS Scientist Training Programme (STP), which provides training for science and engineering graduates to work in healthcare science roles and to the Higher Specialist Scientific Training Programme (HSST) [35], which provides clinical scientists with the deeper knowledge and skills to become eligible for consultant clinical scientist posts.

MR clinical scientists contribute to academic teaching across a range of advanced MR techniques, including undergraduate and postgraduate degree programmes and the MR component of the Fellowship of the Royal College of Radiologists (FRCR) curriculum [37]. MR clinical scientists also supervise postgraduate research projects at master's and doctorate levels through university collaboration.

Clinical Scientific Computing and Informatics

The growth of MR has led to new challenges and opportunities in how information is managed. MR clinical scientists are well placed to use their scientific computing and informatics skills to improve how this information is received, processed, shared, and integrated with other healthcare systems. MR clinical scientists may lead on these developments, to take advantage of new computing technologies and to collaborate with IT services and PACS teams to deliver better, more efficient solutions.

In some instances, MR clinical scientists may be developing medical devices such as in-house software solutions. To practise this safely a high level of computing skill and a good knowledge of the MHRA's medical device regulations [32] are required. MR clinical scientists also contribute to the assessment of emerging technologies, for example, artificial intelligence solutions that use MR data.

In research, development and innovation MR clinical scientists can further contribute to scientific computing and informatics challenges by delivering time saving and robust data management and image processing solutions.

Scientific Leadership

Good leadership requires the ability to think strategically, be imaginative, create a vision and achieve this vision through effective problem solving, team motivation, inspiration and management. MR clinical scientists show strong leadership in leading clinical projects and research teams as well as training, teaching and mentoring. A lead MR clinical scientist plays a key role in driving service improvement, development and cost reduction through service accreditation, leadership and professional interaction. By applying a balance of clinical, scientific, technical and management skills to support complex services with large multidisciplinary teams, scientific leadership in MR physics can enable healthcare providers to deliver diagnostic and therapeutic procedures while managing risk [39].

Conclusion

The MR clinical scientist is a key individual in the multidisciplinary field of MR, helping to deliver a safe, high-quality, efficient and innovative service. They are MR safety experts, educators, trouble-shooters, leaders and innovators who support the full range of clinical and research MR services and use their scientific skills to improve patient diagnosis and treatment.

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Drafted by the IPEM MR Special Interest Group

Contact: Michael Hutton, Consultant Clinical Scientist, The Christie NHS Foundation Trust

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