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MRI simulation for Anal and Rectal Cancer - optimising the patient experience

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Magnetic Resonance Imaging (MRI) simulation is the acquisition of MRI sequences in the radiotherapy treatment position for radiotherapy treatment planning purposes. The primary benefit of MRI simulation within the radiotherapy treatment pathway is the improved soft tissue contrast of MRI compared to CT which improves the visualisation of target volumes and organs at risk (1,2). It's prevalence around the world is varied and dependant on the availability of dedicated MRI simulation equipment (3). Within the UK, only 6 % of radiotherapy patient treatments employed MRI guidance in 2018 and only two radiotherapy centres had dedicated radiotherapy MRI equipment (4). However, the rationale for the increased use of MRI simulation in radiotherapy is building, through increased evidence of the benefit to patients (5–8), the development of new techniques such as MRI-only planning (9–11), and recommendations from national bodies on commissioning and use (12,13). A recent IPEM international survey of MRI use in radiotherapy shows a significant number of centres are planning to implement MRI simulation in the next 5 years (3).

As radiotherapy centres progress with commissioning and implementing MRI simulation, it is important that patient comfort is prioritised and that the complexity of integrating MRI simulation into radiotherapy pathways, from a patient perspective, is not overlooked. CT and MRI environments are substantially different, with MRI scans requiring the patients to remain still in a noisy, enclosed position for a substantial length of time. These features of MRI scanners are due to the large superconducting magnets required - the noise is a bi-product of movement (gradient coils) within the scanner as images are acquired, the enclosed position allows the magnetic field to be uniform within the scanner which is necessary for geometric accuracy and the length of time is required for producing good image quality (14). In addition, MRI scanning rooms are often deliberately cold to help prevent patients from overheating as MRI scans can cause patient body temperatures to increase due to radiofrequency energy being deposited in tissue as images are acquired (14).

It is known that the MRI environment directly affect patient experience (15). Therefore great care is needed to ensure that MRI simulation pathways are commissioned such that the patient experience of MRI simulation is optimal and the consequent patient radiotherapy treatment experience isn't detrimentally affected. This is important to ensure patient treatments are as comfortable and positive as possible and also because patient discomfort results in a higher likelihood of scan motion artefacts (16) which can impair the quality of the acquired data and have negative consequence on their treatment planning. This is challenging as most radiotherapy departments have limited experience of delivering MRI acquisition prior to implementation, and as CT and MRI are so different, we cannot rely entirely on our previous CT based commissioning experiences (3).

Diagnostic MRI patient experience studies show that that patients can experience anxiety or claustrophobia prior to or during an MRI scan (16) and that anxious patients are more likely to move resulting in motion artefacts which impairs the quality of the acquired data. However, while we can learn much from diagnostic imaging studies, radiotherapy imaging differs due to the requirement for specialist immobilisation equipment and specific preparation and scanning protocols which limits the suitability of comparisons.

In our centre we investigated the patient experience of MRI simulation for anal and rectal cancer patients compared to standard CT simulation (15). Radiotherapy CT and MRI simulation scans were acquired for 46 anal and rectal cancer patients with matched clinical pathways. We found that MRI simulation for radiotherapy treatment planning purposes can be a comfortable and positive experience that is comparable in experience to standard radiotherapy CT simulation. This is important as it provides confidence that MRI simulation can be implemented into widespread use within radiotherapy without introducing unacceptable patient experiences. This study identified 4 simple recommendations for an MRI simulation pathway which optimises patients' experiences. These were:

1. The default use of earplugs and headphones with music to reduce noise and provide distraction.
2. Blankets to ensure warmth.
3. Being scanned feet first rather than head first where possible to prevent patient's heads from entering the scanner bore and therefore reduce claustrophobia.
4. Minimising the scanning time to limit discomfort.

To our knowledge, the only other MRI simulation patient experience study in the literature assessed the MRI simulation tolerability for patients with lung cancer, and found that one third of patients had adverse anxiety during their scan, recommending that patient comfort should be a key consideration when optimising the MRI simulation pathway (17). Our recommendations provide practical advice which builds on their findings and highlight the importance of taking into account the differences in scanning environment between CT and MRI to maximise comfort. Particularly, this includes the importance of optimising MRI simulation protocols such that the time on the MRI couch is at its minimum. The length of scanning time is a fundamental difference between the imaging modalities which accentuates the other differences in patient environment. It's easy to attempt to compare MRI simulation to diagnostic MRI scans in terms of acquisition time, and consider MRI simulation to be similar in length; however an obvious difference is the patient position required for radiotherapy which can be uncomfortable due to the necessary immobilisation.

It is notable that in some diagnostic MRI departments interventions such as the four recommended above, for diagnostic MRI scans, are common practice. However for radiotherapy centres, MRI simulation is a new intervention and so experience within departments of MRI protocol optimisation for RT purposes is limited. These learning points highlight the challenges of MRI simulation to radiotherapy centres and the benefit of working closely with radiology departments to fully understand our pathway differences.

MRI simulation can be used in combination with CT through co-registration or alone through MRI-only planning (the use of MRI alone, without co-registration to CT) for planning external beam radiotherapy treatments. MRI-only planning has the additional benefits of removing the need for the CT scan for dose calculation, streamlining clinical efficiency and removing systematic MRI to CT registration uncertainties (1,2,18,19). While there is significant interest in MRI-linac treatments at present, MRI-only planning can be more widely used and should be viewed as a complimentary and more accessible treatment option. This view is supported by the findings of the IPEM international survey where significantly more interest

was shown in the adopting the use of MRI-only radiotherapy than MRI-linacs by radiotherapy centres (3).

The introduction of MRI-only planning has now become a reality within the pelvis, with a number of specialist centres world-wide detailing their experience of treating prostate cancers in the literature (9). The foundations for wide-spread use are now in place, including technical advances and national guidelines providing guidelines for installation and commissioning of MRI simulation equipment (20–24). Importantly the key challenges preventing the wide-spread adoption of MRI-only planning for other pelvic sites are beginning to be tackled in the literature on a site-by-site basis (9,25–32).

Our patient experience study was part of a wider MRI-only radiotherapy study: "Mri-only treAtmeNT planning for Anal and Rectal cAncer radiotherapY" (Manta-ray), research ethics committee (REC) reference: 18/LO/1298, ISRCTN Registry: ISRCTN82734641. Manta-ray aimed to assess the four key challenges associated with MRI-only planning for anal and rectal cancers including; dosimetric accuracy (26), patient position verification accuracy, the patient experience of MRI simulation (15) and the impact of using MRI-only planning on radiotherapy treatments. It aimed to support the wide-spread implementation of MRI-only planning and has provided evidence supporting the technical achievability, the feasibility of clinical implementation and the potential benefit to patients of MRI-only planning for anal and rectal cancers.

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