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Images and images: Current roles of therapeutic radiographers

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ABSTRACT

Introduction: Therapeutic radiography is a small profession and has adapted in response to advanced techniques. An increase in on-line adaptive MRI-guided radiotherapy (MRIgRT) will require role extension for therapeutic radiographers (TRs). This study will investigate the current role description for TRs and the activities they currently undertake with regards to MRIgRT.
Method: A training needs analysis was used to ask TRs about their current roles and responsibilities and essential skills required for MRIgRT. For the purposes of this paper, the authors present the results from the demographics of the individual, their current job title with roles and responsibilities, and experience with decision making and image assessment. Descriptive statistics was used to analyse the data.
Results: 261 responses were received (n = 261). Only 28% of job titles listed contained the protected title of 'therapeutic radiographer'. Advanced clinical practice roles were expressed by participants indicating that if a service need is presented, emerging roles will be created. Variation existed across the standardised roles of TRs and this discrepancy could present challenges when training for MRIgRT. TRs are pivotal in image verification and recognition on a standard linac, and skills developed there can be transferred to MRIgRT. Decision making is crucial for adaptive techniques and there are many skills within their current scope of practice that are indispensable for the MRIgRT.
Conclusion: It has been demonstrated that TRs have a range of roles that cover vast areas of the oncology pathway and so it is important that TRs are recognised so the pivotal role they play is understood by all. TRs have extensive soft-tissue IGRT knowledge and experience, aiding the evolution of decision-making skills and application of off-protocol judgments, the basis of MRIgRT.
Implications for practice: Role development and changes in education for therapeutic radiographers.

Introduction

Therapeutic radiography is a small profession[1] and has struggled with recruitment, retention, and recognition.[2,3,4,5] The increasing demand on the National Health Service (NHS),[2,6,7] increased advanced techniques required for radiotherapy,[8,9] alongside a shortage and/or availability of key radiotherapy multi-disciplinary team members (MDT)[2,10,11] has exacerbated the situation. Therapeutic Radiographers (TRs) play a pivotal role within radiotherapy and, to maintain efficient radiotherapy delivery,[2,8,12,13] have adapted roles in response to advanced techniques. Such as soft-tissue image-guided radiotherapy (IGRT),[14,15,16] stereotactic ablative radiotherapy (SABR)[17] as well as non-treatment delivery activities such as site-specialist[18,19] and treatment-review TRs.[2,20,21] Many of these roles fall under advanced clinical practice (ACP), 'a level of practice characterized by a high degree of autonomy and complex decision making',[22] which also could be applied to on-line adaptive Magnetic Resonance Image-guided radiotherapy (MRIgRT). The new tasks and skills of TRs daily acquiring MRIs, re-contouring, and re-planning to compensate for intra- and inter-fraction anatomical changes, using motion management techniques and/or biological targeting, and assessing the quality of a plan for a fraction within a course of radiotherapy treatment all offers the potential for ACP.[23] However, role extension is needed because many required skills are not routinely taught at undergraduate level.[2,10,24] In some MRIgRT settings, TRs are already performing roles that were previously the remit of other MDT members to streamline the workflows and facilitate easier implementation.[24,25,26,27,28] In other MRIgRT centres, the number of treatment sites are increasing due to the success and tolerability of the pathway.[26,27,29] Good, 'standard'

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radiotherapy skills are a necessity for MRIgRT and subsequent role development[10,24] and is the case with other role extensions, advanced technique developments, and for existing ACP TR roles.[14,18–21] This report is part of a larger study investigating skills and knowledge required to deliver adaptive radiotherapy (ART).[24] A baseline of TRs skills is presented here to set the context in which MRIgRT is being implemented.

Methodology

A training needs analysis (TNA) was created using the Hennessy-Hicks model[30] containing identified MRIgRT skills for UK-based TRs.[24,31] This method was chosen to allow quantitative data collection and expression of qualitative data regarding the skills required of a TR to deliver ART, obtain several perspectives, and ascertain training need requirements and preferences.[30] A pilot TNA was sent to six TRs to check for clarity, estimate time of completion, and to ensure the efficacy of the questionnaire. Based on the feedback provided, the TNA was streamlined, consistency improved, and formatted for ease of completion. The questionnaire comprised of five sections (Appendix 1). Section 1 covered the demographics of the individual TR, their job title, and graduate education. Section 2 asked about their current roles, responsibilities, and experience with decision making and image assessment. Section 3 asked the participants about identified skills required for MRIgRT and whether they could or could not perform the skill, whether it was important to their current role and future of therapeutic radiography, and whether they had undertaken training and preferred training methods. Section 4 asked the individual about their experience and views on ART. Section 5 asked individuals to rank the skills in Section 3 in order of importance to their current and any future roles. The inclusion criteria stated participants must be a UK-based TR registered with the Heath and Care Professions Council (HCPC). No prior experience of ART was required and by undertaking the TNA implied consent was obtained. Electronic invitations were sent to all UK radiotherapy centres via email to radiotherapy service managers, a previously used successful method,[32] and the 'Research and Clinical Trials Therapeutic Radiographers Network' (RaCTTR). Advertisement was placed on social media (Twitter© and LinkedIn©). The aim was to reach at least three radiographers from every UK NHS centre. Invitations were sent to independent UK radiotherapy centres. Local Committee for Clinical Research, Health Regulations Authority, and Health and Care Research Wales approval was obtained. All participants were assured of confidentiality and anonymity of results. For the purposes of this paper, as described above, the authors present the results from Sections 1 and 2. Descriptive statistics was used to analyse the data.

Results

The TNA was open between June and October 2021. A total of 261 (n = 261) responses were received from 75 (96%) UK NHS radiotherapy centres and three independent UK radiotherapy centres.

Current role

There was an even distribution regarding the length of time qualified as a TR (Table 1). Over two thirds of participants (69%) had a form of post-graduate education or accreditation certificate with the most common being an MSc module (62%), followed by a MSc (28%) and PGDip (22%) and four participants had a PhD.

From the data, 95 different job titles were reported (Fig. 1) and 33 participants were in split roles (13%) therefore, the total individual job titles listed was 294. The most common job title was 'Therapeutic Radiographer ± Banding ± Senior' (n = 67). The title was used an additional 15 times in combination with a speciality and thus, present in 28% of the job titles. There were 46 (13%) job titles under the heading of advanced practice/site specialist roles and 24 (8%) under a leadership heading. Only 5% of the job titles listed expressed speciality in pre-treatment, planning, and dosimetry and 6% were treatment specific titles. A tenth of job titles listed were specialised in research, education, and development.

Roles and responsibilities

Just over half of participants (53%) stated they participated in the pre-treatment pathway. Of those, the highest activities were planning CT (88%), mould room (41%) and cannulation (37%). Of those, 6% reported they could perform planning MRIs. Under a third (32%) of participants had options to rotate through planning and dosimetry. Under half of participants (42%) disclosed they could undertake planning and checking of radiotherapy plans. Of those, the most common activity was virtual simulation (87%) (Fig. 2).

Many participants (85%) engaged in radiotherapy setup and/or treatment delivery. Of those, the highest reported activities were C-Arm linac (78%) and superficial unit (29%). A fifth of participants had been involved with ART either on a C-Arm linac (17%) or MRI-guided linac (3%). Most participants (90%) engaged in image verification. Of those, the highest activity was Cone-Beam computed tomography (CBCT) (Megavoltage (MV)/Kilovoltage (KV)) (95%) (Fig. 3).

Almost a fifth of participants (19%) expressed involvement in follow-up and/or review of radiotherapy patients, with the most common activity being on-set treatment review (n = 20) and post-treatment review and advice (n = 10). Just over two thirds of participants (67%) stated they were involved with the development and education of TRs and TR students.

Over a third of participants (34%) were involved directly in research and/or trials and of the highest activities from those participants were audits (89%) and service evaluations (75%).

A small percentage of participants (4%) could triage and refer patients for radiotherapy with participants able to refer patients for palliative (n = 3) and radical urology radiotherapy (n = 2). A small number of participants (6%) could consent for radiotherapy with the most common being consent for urology radiotherapy (n = 3). Less than 10% of participants (8%) could prescribe pharmacy to patients undergoing radiotherapy and the majority was under a patient group directive.

Table 1
Length of time participants were qualified as a Therapeutic Radiographer (TR) in relation to decision making.

Length of time qualified	No of participants	No of participants who can refer for plan assessment	No participants who can undertake a plan assessment	No of participants who can authorise a decision from plan assessment	No of participants with imaging decision tool experience	No of participants with experience selecting from a library of plans
0–5 years	68	64	10	8	17	19
6–10 years	64	61	13	13	26	17
11–15 years	46	45	18	20	13	17
16–20 years	36	36	16	8	16	16
21+ years	47	43	9	11	12	14
Total	261	249	66	60	84	83
	100%	95%	25%	23%	32%	32%

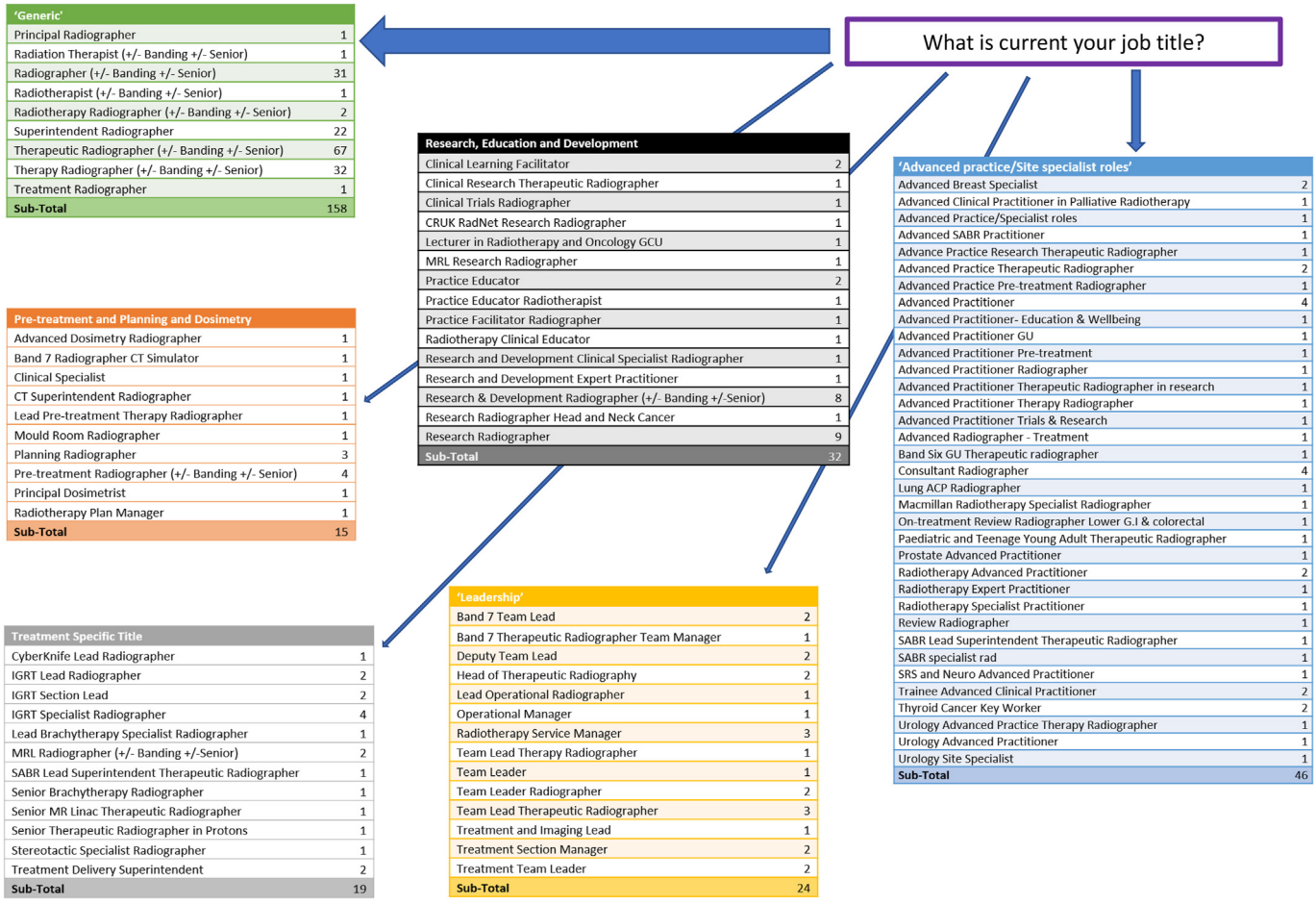

Figure 1. Current Job titles.

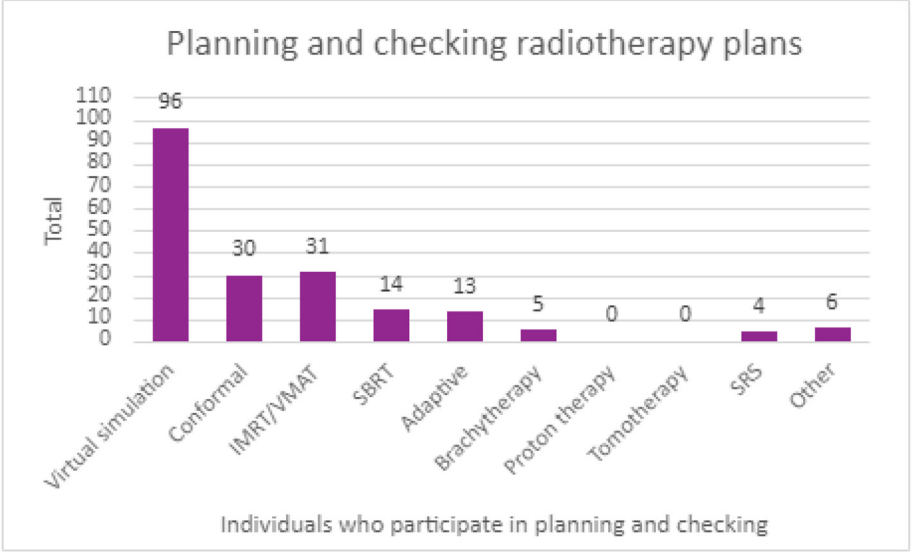

Figure 2. Radiotherapy plans: Planning and checking activities.

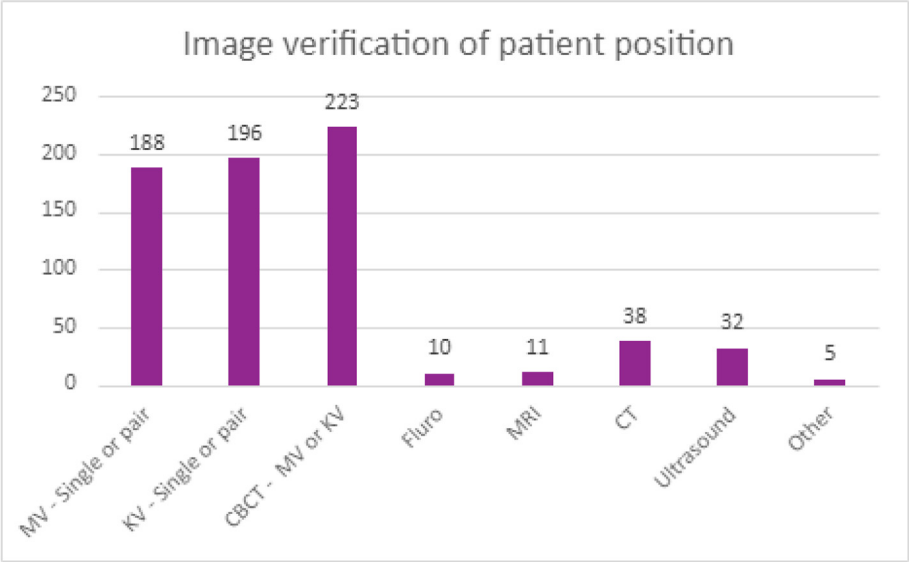

Figure 3. Radiotherapy Imaging: Image verification activities.

Over a quarter (26%) stated they were involved with the development and education of other healthcare professionals.

There were 34 additional responsibilities described (Table 2). The most common title documented was 'SABR ± lead' (n = 47). A total of 25 participants stated they were an 'IGRT specialist ± lead'.

Most participants (95%) could refer an on-treatment plan for assessment and/or review but only a quarter could undertake this task and less than a quarter (23%) could authorise a decision of the assessment and/or review. The distribution of percentage of TR's who referred for plan assessment was similar overall years of experience but TRs with 11–15 years and 16–20 years of experience were the majority when undertaking plan assessment (39% and 44%). Authorising decisions was most common in 11–15 years (<40%) (Table 1 and Fig. 4).

Just under a third of participants (32%) had experience using traffic-light decision tools and the most common sites where this was used were prostate, cervix, and lung, respectively. The highest percentage with imaging decision tool experience was 16–20 years (44%) and 6–10 (41%) (Fig. 4). Just under a third of participants (32%) had experience with selecting radiotherapy plans from a library. The highest percentage with library of plans experience was 16–20 years (44%) and 11–15 years (37%) (Fig. 4).

Discussion

Although the majority of TR's remain directly involved in the planning and delivery of radiotherapy the roles and responsibilities and in particular, job title, varied across the UK.

Current role

Less than a third (28%) of participants used the UK protected title of 'therapeutic radiographer'. Either a generic term was used or the term 'therapeutic' was omitted from specialised roles. Conversely, in other studies 'therapeutic' was used significantly more than 'therapy' (87% vs 26%).[33] However, this evidence came from the professional body of TRs and was completed by a single spokesperson for each radiotherapy provider rather than individual

Table 2
Additional roles expressed by Therapeutic Radiographers (TR) in the training needs analysis (TNA).

Additional Roles	Total
Imaging and verification	
Fiducial Marker Insertions	2
IGRT Specialist ± Lead	25
Planning and dosimetry	
Specialist Dosimetrist	1
Site specialist	
Brachytherapy	1
Breast	6
Gynae Brachytherapy	1
Lung	1
Paediatric	3
Skin	2
Urology	5
Review	
Non-Medical Referrer	1
On-Treat Clinic Review	1
Pacemaker	1
Patient-Support	2
Radiographer-Led MSCC Prescriber	1
Resuscitation Core Worker	1
Treatment technique	
Adaptive Radiotherapy ± Lead	6
New site/Technical Lead	6
Proton	4
Respiratory Gating ± Lead	1
SABR ± Lead	47
SRS ± Lead	6
SGRT	2
TBI	2
Other	
AI ± lead	1
Auditor	2
Clinical Governance	1
HCPC Partner	1
Manual Handling	1
Recruitment Lead	1
Risk Management	1
RTDS Data	2
Union Representative	2
Well-Being Lead	2
Total	

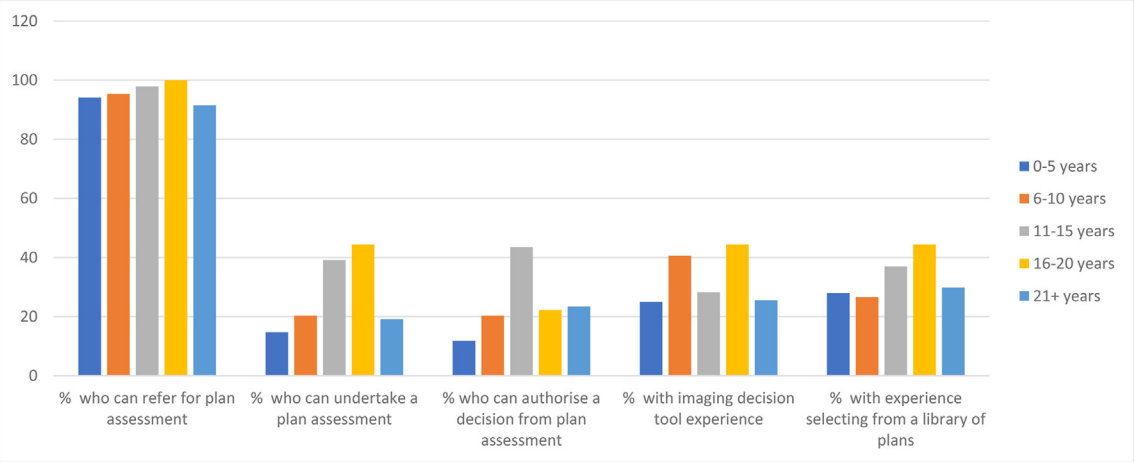

Figure 4. Percentage of radiographers by experience who can perform tasks.

TRs. It could indicate that there is preference for specialised job titles that could be lengthy thus 'therapeutic' is excluded and 'radiographer' remains. Nonetheless, it will be difficult to pioneer role development when TRs are not unanimously behind the HCPC protected title of a small healthcare profession[4,5] and this is recognised outside the UK.[34] Other interesting aspects were the number of different job titles reported by participants (n = 95), including the number of ACP roles (Fig. 1) and the additional roles that TRs hold which were not considered part of their job title (Table 2). Many contributing factors could be considered. Emerging roles will appear alongside service demands despite barriers because TRs will adopt new practices to meet service needs. Fig. 1 and Table 2 demonstrates that TRs are present in many areas of oncology including research, education, and development. Many of these roles have been formed to support new and advanced techniques, and to ensure other TRs have the support and training required. Subsequently, new practices become standard and/or current practice and TRs have adapted to the change. The new skills and knowledge have been absorbed without recognition of role extension or role advancement. Education through accreditation is recommended for TRs involved with MRIgRT.[3,9,10,35] The high proportion of participants with post-graduate education, although this may be a self-selected sample, demonstrates the profession's investment in education. The benefits gained would include a standardised competency for all ACP roles not just MRIgRT and a reduction in inequalities in access to care across the UK.

Roles and responsibilities

Although most respondents engaged in radiotherapy setup and/or treatment delivery (85%) and (90%) verification, less than 20% had experience of ART. If ART increases, training needs will be present across the TR workforce. The variation across TRs roles and responsibilities reduces the proportion of TR's working within the current Standards of Proficiency (SOPs)[31] and presents challenges when embracing the opportunities created by an MRIgRT role. The contrast between the defined SOPs[31] and the capability of TRs is of interest as the barriers that reside prevent the TR profession from having a uniform workforce. This is evident notably with reference to planning, dosimetry, and pre-treatment activities. Despite the variations, ART training programmes have been implemented successfully in the UK and elsewhere in the world.[8,10,14]

ACP

ACP roles are not new in the UK[18,36] and have been increasing, aligning with the technical advancements and the acknowledgement that a high proportion of radiotherapy work could be performed by TRs in ACP roles.[2,28,37] ACP roles have often been roles formally held by other healthcare professionals, not only for TRs but other NHS healthcare professions.[38,39,40] Novel roles soon become established into the routine workflow[2,9,18] and was demonstrated by the number of TRs who identified themselves in a SABR or IGRT role in their job title and additional roles (Fig. 1 and Table 2). The line between ACP and routine clinical practice blurs with time.[10,28,35] A more adaptable model would be incorporating aspects of ACP into current roles. The challenges of gaining continuous funding with the need for regular training and auditing, increases resistance and places a strain on departments.[8,41] Especially with the increasing need for patients requiring radiotherapy and a shortfall in the TR workforce.[2,3,9] MRIgRT may not be seen as a priority in UK centres given the demand on resources in conjunction with the inconsistent planning and dosimetry experience of TRs.[41,42] As the main planning activity was VS and the uptake in other modalities is low (Fig. 2), there will be a lack of clinical urgency to change current practice. However, training in MRIgRT skills will bring additional knowledge to departments which will be advantageous for many aspects of the treatment pathway and maintain the radiotherapy workforce.

Education is a core pillar.[22] TRs need to be able to actively feed back into their departments through teaching, maintaining competence, and cascade training not only for MRIgRT but also for the range of their scope of practice and ensuring training is up-to-date and in line with evidence-based practice. Although some mentioned (26%) they participated in the education of TRs and other healthcare professionals, it will have to become a standard for ACP MRIgRT individuals.

Research is a core pillar.[22] Some participants stated they engaged in research and the HCPC states that there should be an awareness in auditing and monitoring quality.[31] As it stands, this does not meet the ACP criteria[31] as there needs to be critical engagement and appraisal, and evaluation and synthesis of evidence-based practice and governing practice. This depth of involvement may be unfamiliar[43,44] as the most reported activities were audits and service evaluations. Therefore, a collaborative working environment with current research TRs, like RaCTTR, will be of important to help upcoming ACP TRs to progress to the level required and will provide a

network of support. This is recognised as an area of required development.[44,45] Many TR ACP roles currently occur away from the linac as demonstrated by respondents with roles such as triaging, referring, consenting patients for radiotherapy, and prescribing pharmacy products[2,46] and from Fig. 1 and Table 2. These roles are pioneering, demonstrate that TR ACP role development is occurring and are supported by the profession's professional body[47] and this is the case for ACP TRs outside of the UK including those involved with MRIgRT.[10] However, a MRIgRT ACP role would allow for clear and defined role expansion and progression around the core-components of radiotherapy, creating expertise and allowing for optimisation of resources at the centre of treatment delivery.

Training

Clinical practice is essential[22] and the skills needed for MRIgRT will require training for TRs. Over half of TRs (54%) stated they participated in the pre-treatment pathway, and less than 10% could undertake an MRI scan, a key-skill required for MRIgRT.[24] Under half of the participants participated in planning and checking of radiotherapy plans, a defining skill of MRIgRT but those who have experience are mostly involved in virtual simulations planning (Fig. 2). Both activities are a requirement by the UK's governing body[31] but only half of participants are performing them. The lack of experience is recognised as a barrier by TRs working MRIgRT.[24] Without addressing the inadequate planning and dosimetry experience, a considerable proportion of the TR profession is at risk at losing a specified and invaluable skillset. This indicates the significant amount of training required for MRIgRT and the obstacles preventing all UK TRs from being competent in pre-treatment and planning activities. The reasons as to why uptake in pre-treatment and planning activities are low is multifactorial. UK undergraduate programmes may focus on radiotherapy treatment delivery activities therefore there is more preference and familiarity with treatment setup and/or delivery. Radiotherapy planning and dosimetry is performed mostly by non-patient facing TRs and physicists. This continues a tradition which, unless change happens, will continue.[34] Despite most participants having a form of post-graduate education, a small number had any advanced planning practice. If training in planning and dosimetry became more accessible, it will not only alleviate pressure on other professionals and increase patient through-put but also increase the skill set of TRs, empower the profession, and meet the HCPC SOPs, and improve recruitment and retention.[9,31,35] This has been seen with review-radiographers.[20,48]

MRI and other multi-modal imaging are becoming integral to the radiotherapy pathway[41,49] and TRs will need to adapt. It is identified MRI training requires the support of diagnostic radiographers and departments.[12,24] With MRI becoming more integrated throughout radiotherapy pathways, TRs will need to become conversant to meet this growing requirement.

The second largest activity by TRs was radiotherapy setup and/or delivery. This builds fundamental radiotherapy skills, including problem-solving, which has been identified as a necessity for MRIgRT.[14,24] The depth of experience gained from day-to-day radiotherapy practice will be of immense importance when working on MRIgRT pathways which demand high-levels of TR involvement and decision-making.[14,24] Of the participants involved in radiotherapy setup and/or delivery, a fifth were involved in ART. Although 3% were involved with an MRI-guided linac, it shows TRs are building experience with ART which helps build a foundation of knowledge[14,24] but still leaves a sizeable proportion with insufficient exposure. As ART becomes more accessible and biologically favoured, TRs will need to become accustomed to the ART pathway.

The most common activity reported by TRs was image verification. IGRT is the standard of care in the UK and TRs have refined and advanced the process.[12,16] Although 5% could undertake MRIs, 95% used CBCTs for image verification, illustrating the high proportion with experience of soft tissue registration (Fig. 3). Soft tissue registration and recognition are key skills for ART[24,41] and for many treatment sites and techniques.[15,16] The extensive experience TRs have from C-arm linacs has been shown to be transferable to MRIgRT.[15,24] This is not only important for MRIgRT but also the integration of MRI into C-arm linac radiotherapy, which is becoming more widely used.[17,50,51] It is essential that training programmes for new and/or complex techniques are robust as the additional training requires a collaborative effort between MDT members, the support of multiple centres, and radiotherapy education providers.[8,10,14,15,24,50] Especially given the small number of UK centres performing MRIgRT[52] and the complexity of the ART pathway.[14,25,50]

Decision making

Decision making is crucial for ART techniques[10,14,15,24] and despite participants lacking training in key MRIgRT skills, there are transferrable skills within their scope of practice that are indispensable[24] and expressed in the TNA. Other professions have clinical reasoning education imbedded in their pre-registration courses and is as a necessity for TR registration.[8] Despite radiotherapy being protocol-driven and off-protocol decisions unfamiliar, there are TRs who have adapted to this change.[8] Around a fifth of participants expressed they engaged in participating and/or leading SABR in their departments. With higher doses per fraction, smaller PTV margins, and soft tissue imaging being used, radiographer led SABR is a driving force for role development.[53] It has comparable elements with MRIgRT and demonstrates that non-MRIgRT TRs are assessing soft tissue and making the decision to treat or to intervene without clinician presence.[53]

There is a significant difference between TRs being able to recognise a concern with a plan and being able to act on it (Table 1 and Fig. 4) which, in an offline setting, TRs should be able to execute under the HCPCs SOPs.[31] The indication that 95% can refer for an assessment but only 23% can authorise a decision is a concern. Especially as it is irrespective of length of time qualified as a TR (Table 1 and Fig. 4). Deciding whether a plan is acceptable for treatment based on the evidence presented is a skill required for MRIgRT.[24] A considerable proportion of this work is performed by MDT professionals when TRs could perform the task. This skillset is indispensable across the radiotherapy pathway and could lead to quicker action and decision times as TRs would be responsible rather than waiting on other MDT members. TRs will need to be able to accomplish this to participate MRIgRT. The success of implementing ART is to have robust procedures in place.[8,15,50] TRs have demonstrated skills in image pattern recognition and evaluation that have allowed 'traffic-light' protocols to be embedded in areas of treatment delivery with success.[8,14,41] These robust protocols could be ingrained in MRIgRT protocols to allow TRs to act on plan concerns.[24] Just under a third of participants had experience using traffic-light decision tools and using a library of plans. Although there was no direct correlation between length of experience and decision making, TRs between 11 and 20 years of experience were the most common undertaking plan assessment and library of plans. This represents those working clinically, with those more than 20 years working in management roles. This shows that TRs are becoming more familiar with decision making regarding optimum plan selection and treatment delivery and making treatment-based decisions based on deviations presented. Although this method has been advantageous since 2013,[54,55] it is a small proportion of TRs with experience with some centres reporting none. Progress with multi-modal imaging is occurring. A single centre study has demonstrated that TRs can competently match MR-CBCT with

comparable results to CT-CBCT.[56] The transferable skills identified here, and the potential of this data is very promising and will hopefully propel more centres to trial this and assess their TRs.

Future

MRIgRT requires skills that are outside the current scope of practice for TRs, and it is crucial to find the importance of these for current and future roles. This was investigated in Section 3 of the TNA and will be presented as a follow-up to this publication. Despite MRIgRT having attractive features of ACP for TRs, it is worth keeping in mind the difficulties: the continuous credentialing, funding, and education. Novel roles become widely accepted as standard practice which leads to different views on ACP and what is just changing standard practice[35,57,58] and this can be supported by data in Table 2 and Fig. 1. Accountability, scope of practice, and education is the foundation of ACP but there is evidence that post-graduate education is not enough to demonstrate ACP.[3,9,59] Therefore, consideration must be given on how this ACP role develops and progresses.

Limitations

In terms of the sample, 8% of the UK TR population were represented,[1,33] an equal proportion of length of time TRs had been qualified were sampled (Table 1), and responses were received from 96% of UK NHS trusts. There was a high proportion of participants with post-graduation education which may have biased the sample but could represent that more roles are requiring post-graduate education. Although adaptive experience was not a requirement, some TRs with no or little experience may have avoided participating. The TNA did not ask any specific leadership questions, a pillar of ACP.[22] As seen in Fig. 1, there are many TRs in leadership roles, but this warrants further investigation to see the proportion in senior leadership roles. The questionnaire was open during a global pandemic,[60] and radiotherapy service managers reported staff shortages due to isolations, restrictions, and increased patient workload. Thus, asking TRs to answer a non-mandatory questionnaire was difficult.

Conclusion

Despite a protected title, titles used by UK TRs are not consistent resulting in the risk of lack of identity and it is demonstrated that TRs have a wide range of oncology pathway roles. It is important that TRs are recognised to ensure the pivotal role they play is understood by all as the TR role is evidenced as multi-faceted. With advancements in radiotherapy still progressing, it is required to make these roles clear and well defined to ensure support, resources, and responsibilities are timely and appropriately delivered. The diversity within TR roles may cause difficulties when seeking to train a TR workforce capable of undertaking MRIgRT. ACP roles offer the potential to progress MRIgRT, but attention will be required to ensure it encompasses all factors to support TRs. TRs have extensive soft-tissue IGRT knowledge and experience, aiding the evolution of decision-making skills and application of off-protocol judgments, the basis of MRIgRT. However, a concerning factor was the lack of consistency in skills across the sampled population and the TRs not meeting the HCPCs SOPs.[31] Any barriers in TR training and experience warrants further investigation.

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Conflict of interest statement

There are no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2022.07.016.

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