

Image Guided Radiotherapy (IGRT) Clinical Support Programme in England 2012 -2013

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Foreword

In 2007, the National Radiotherapy Advisory Group (NRAG) report 'Radiotherapy: developing a world class service for England' was published. This set the commitment to develop and deliver world class radiotherapy for the benefit of cancer patients in England. Within the NRAG report, the concept of 4D Adaptive Radiotherapy was developed. The concept that you could visualise and adjust the radiation beam in real time to match the target treatment volume, accounting for changes in tumour position and patient movement, were revolutionary. This allowed the clinical community for the first time to think what may be possible if we were to be able to offer truly individualised therapy at the point of each delivery.

In order to deliver the concept of 4D Adaptive Radiotherapy, Image Guided Radiotherapy (IGRT) is an essential element. The ability to visualise the tumour in the treatment setting and then be able to use that information and adapt the treatment plan is vital.

In a Government Press release dated October 2012, the Prime Minister, David Cameron, set out that all patients would 'have access to the most appropriate, safe, and cost effective radiotherapy that their doctor recommends'. Access to IGRT is a key part of meeting this pledge.

This report sets out the work that has been done to support clinical services delivering advanced levels of IGRT. I would encourage providers and commissioners to consider both the report and its findings. They will be important as we move ahead with world class radiotherapy in England.

Sean Duffy

National Cancer Director

NHS England

References

National Radiotherapy Advisory Group, 2007. Radiotherapy: developing a world class service for England
http://www.axrem.org.uk/radiotherapy_papers/DH_Radiotherapy_developing_first_class_service_NRAG.pdf [accessed 17.08.13]

Department of Health Press release, 8th Oct 2012
<https://www.gov.uk/government/news/eight-thousand-patients-to-benefit-from-advanced-cancer-treatment>

Executive Summary

Following publication in 2012 of the National Radiotherapy Implementation Group (NRIG) report, IGRT: Guidance for Implementation and Use,¹ the National Cancer Action Team (NCAT) funded an Image Guided Radiotherapy (IGRT) clinical support programme. Its purpose was to expedite the implementation and uptake of IGRT technology and techniques throughout England, thus enabling the future implementation of 4D adaptive radiotherapy (4D-ART).

The programme was delivered by a multi-professional team (MPT) of clinical experts. The MPT comprised two 0.6 whole time equivalent (WTE) radiographer IGRT Leads, whose role was to provide on-site support for centres in reviewing current practices and developing protocols and work instructions. Physics support was provided by three English radiotherapy centres as an outreach service via e-mail or telephone. Specialist oncologist support was directed as appropriate by the co-chair of the NRIG IGRT sub-group. All centres received a tailored report with recommendations for continued implementation of IGRT.

This final report describes the process, methods and outcomes of the NCAT IGRT clinical support programme. It demonstrates progress made and highlights the significant challenges that remain. Recommendations have been formulated for radiotherapy service providers, NHS England Specialised Commissioning, education providers, professional bodies and equipment manufacturers.

The National IGRT team leads were Therapeutic Radiographers; June Dean and Mark Elsworthy. Physics support was provided by Clinical Scientists from three radiotherapy centres in England; Addenbrookes, Clatterbridge and Nottingham.

Summary of main recommendations

Radiotherapy service providers:

- Risk assessments must be completed when implementing new technology and techniques. This is made clear in the NRIG IGRT report.¹
- Training workbooks for MV/kV planar imaging and 3D volumetric imaging are desirable.
- The roles and responsibilities within local protocols must be reviewed for those individuals justifying non-planned imaging dose to ensure that they are in-line with IR(ME)R Legislation and guidance.^{2,3}

- It is important that all centres regularly review their IR(ME)R procedures in terms of training records for entitled practitioners and operators (for IGRT) .^{2,3}
- The use of document templates is recommended to ensure continuity in the format of local protocols and work instructions.
- All providers to have access to and use of the eLearning for Healthcare (e-LfH) IGRT module ⁴ as part of local training and competency programmes.
- A database of interesting patient cases that can be used as a training aid to help assess troubleshooting skills should be compiled.
- Developments in applications training must be driven by service providers and reflect local pathway requirements.
- Protected time needs to be provided for the IGRT team including the lead imaging radiographers, clinical radiographers and physicists to enable the development and implementation of IGRT training programmes as recommended in the NRIG IGRT report.¹
- IRMER requires that an assessment of patient dose is undertaken. Imaging doses should be recorded for each patient as a total concomitant exposure received during planning and treatment (Regulation 7, 3(b) of IRMER) .²
- Audit of patient set up error data must become routine practice to help inform local planning margins and justify on-treatment image verification frequency.

NHS England specialised commissioning:

- Clearer guidance for IGRT tariffs is required, in particular that which relates to the use of the 'Adaptive' code Y91.4.
- A new code is required for IGRT linked to levels of complexity as outlined in the NRIG IGRT report.¹
- Future guidance relating to IGRT coding needs to be less ambiguous to avoid misinterpretation and to ensure that its application is standardised.

Radiography education providers:

- Radiotherapy service providers must work with local Higher Education Institutions to develop the minimum requirements to enable new radiographers to be fit for purpose to undertake IGRT as outlined in the Education and Career Framework.
⁵
- Volumetric image analysis and decision making skills need to be developed during the undergraduate and post graduate pre-registration programmes via a standardised IGRT curriculum.
- All education providers are advised to adopt the IGRT training framework outlined in Appendix 7.

Radiotherapy Physics - Education and Training:

- The NRIG IGRT Report recommends establishing IGRT champions from each professional group. Although many centres have physicists nominated for or specifically appointed to IGRT roles it is accepted that many physicists in this position have never received formal training in imaging. It is recommended that stronger emphasis on IGRT is introduced into professional training programmes, possibly at Accredited Expert Scientific Practice (AESP) or Higher Specialist Scientific Training (HSST level) under the Modernising Scientific Careers programme. In addition, support for physicists to participate in relevant CPD activities is strongly encouraged.
- Closer working between physicists working in radiotherapy and diagnostic imaging departments is recommended with the emphasis being on mutual collaboration rather than specific tasks being assigned to one group or the other.

Radiotherapy board (Joint professional bodies: SCoR, IPEM, RCR):

- It is essential that the professional bodies continue to support the work funded by NCAT and not lose the momentum of change that has been established.
- A follow-up survey to assess the progress that has been achieved with regards to IGRT implementation is advisable after 12 months.
- There is an appetite for ongoing and accessible physics IGRT support, possibly via coordinated peer-to-peer mentoring at a regional model. As suggested in the NRIG IGRT Report, one option may be for this to be facilitated by the IPEM dosimetry audit network that is already well established.
- Physicists are also encouraged to utilise the RT imaging special interest group (SIG) 'Google' forum, established by the SCoR and to utilise the medical-physics-engineering@jiscmail.ac.uk listserv.
- Additional work is required to develop protocols for the end to end optimisation of radiotherapy imaging processes.

Radiotherapy equipment manufacturers:

- Applications support needs to include anonymised data sets or possible access to on-line web demonstrations (modular e-learning) for group learning and discussion of non-standard cases for training, reducing the use of phantoms.
- Remote terminal access for off-line review and IGRT training should be provided.
- Access to data for systematic error and population trend analysis, including statistical analysis tools must be made available.

Radiotherapy trials

- The IGRT component of any trial methodology must be clear.³ Work must continue with the Radiotherapy Trials Quality Assurance (RTTQA) group in developing an accreditation method for IGRT that is anatomically site specific.

Regulation 7 (4(d)) of IRMER requires there to be target levels of doses on those doses delivered for research purposes. Links must be made with the National Research Ethics Services (NRES) - <http://www.nres.nhs.uk/about-the-national-research-ethics-service/development-of-the-research-ethics-service/>

National IGRT Team

Final Report

1. Purpose

The purpose of this report is to provide the radiotherapy community in England with feedback from the findings and outcomes of the NCAT IGRT clinical support programme. It describes and analyses what has been achieved to date and makes recommendations for English radiotherapy services in relation to rapid implementation of the National Radiotherapy Implementation Group (NRIG) report 'IGRT: Guidance for Implementation and Use'.¹

1.1 Introduction

The NRIG IGRT Report¹ was published in August 2012. It reaffirms the principles and updates 'On target: ensuring geometric accuracy'.⁶ The report is a guide for radiotherapy services to choose and implement appropriate IGRT techniques in different clinical situations to ensure the best standard of care. It was written to 'support the wider adoption and application of IGRT to enable the future implementation of 4D adaptive radiotherapy (4D-ART) throughout England' .

The report specified that radiotherapy service providers in England should have 'plans in place to move to routine IGRT over the next 12 months'. A whole pathway approach is recommended for all patients, from treatment planning to delivery. Site-specific IGRT protocols should be in place, customised from the generic protocols in the report. It also recommends having a MPT approach and appointing an IGRT Lead for each professional group to coordinate its use.

NCAT subsequently developed a programme of support to be offered to services to permit rapid implementation. The programme was delivered by an MPT of clinical experts. The MPT comprised two 0.6 WTE radiographer IGRT Leads, whose appointment followed a rigorous selection process. Their role was to provide on-site support for centres in reviewing current practices and developing protocols and work instructions. Medical physics teams from NHS radiotherapy centres in England were invited to tender to provide remote technical support alongside the IGRT Lead radiographers. Following the tender process physics support was provided by three English NHS radiotherapy centres as an outreach service via e-mail or telephone. Specialist oncologist support was directed as appropriate by the co-chair of the NRIG IGRT sub-group.

2. Programme Methodology

2.1 Setting the standards

Key standards for measuring an IGRT service, derived from 'On target: ensuring geometric accuracy in radiotherapy' ⁶ and the NRIG IGRT report ¹ were developed by members of the NRIG IGRT sub-group and the National IGRT leads (Appendix 1). By evaluating compliance with these standards, it was deemed possible to tailor support to the needs of individual centres and evaluate the implementation and uptake of IGRT in England at this time. IGRT is defined in terms of levels of complexity; levels achievable by each provider are dependent on equipment available (Appendix 2). Protocol development was to be a key component in advancing IGRT use, especially in support of local equipment and abilities including measuring, recording and justifying imaging doses. Manufacturer support was targeted to facilitate the acquisition of local data for margin calculations.

2.2 The Programme Support Strategy

Each of the 50 radiotherapy providers in NHS England was asked to invite the IGRT Leads to undertake a review visit. Contact was made with each to agree dates and obtain existing documentation for IGRT related protocols and work instructions, and training documentation. A visit pro-forma was provided if needed (Appendix 3), the majority being one day visits. Initially the IGRT leads conducted five visits together in order to ensure consistency in the support provided during subsequent visits that the IGRT leads performed independently. The structure of the visits was flexible to support the needs of the centre and fit in with the requirements of the clinical practice.

2.3 IGRT Lead support

Each visit began with an initial meeting with the IGRT MPT to outline the IGRT support programme and to clarify the focus of the support visit. Following a tour of the department, time was spent observing image review within the treatment control rooms before discussion with key staff regarding protocol and IGRT training development. During the visit, the IGRT leads offered time to meet with the medical physics teams to discuss the NRIG IGRT guidance and general implementation issues, specifically the measurement and recording of imaging dose was discussed and also ways in which the medical physics team could support the treatment

radiographers' IGRT training. At the end of each site visit, headline feedback was provided to the IGRT MPT, followed by an official IGRT review visit report within three weeks (Appendix 4). Each report was independently reviewed by the other IGRT Lead prior to submitting to each centre.

Arrangements for continuing support throughout and beyond the programme were also put in place. These included the setting up of the radiotherapy imaging SIG in October 2012 and an IGRT focus group in May 2013, hosted by the support team.

2.4 Physics IGRT support

Support was to be provided remotely via telephone or e-mail to those departments that had requested support. This was to include advice on implementation of quality assurance (QA) programmes for new IGRT equipment and optimisation of existing IGRT related protocols and work instructions. The physics support roles were awarded to radiotherapy physics teams from Addenbrookes, Clatterbridge and Nottingham hospitals.

2.5 Clinical oncologist IGRT support

IGRT support for clinical oncologists was facilitated as part of the support provided to the MPT at each centre. Should specific clinical support have been required, arrangements were in place for the NRIIG IGRT report co-chair to facilitate this; however no requests were received.

3. IGRT support survey

In the summer of 2012 all NHS radiotherapy centres in England were surveyed using Survey Monkey™ to obtain base line data about IGRT capability and to determine the level of support they were likely to require. Invitations were sent to heads of service for both therapeutic radiography and radiotherapy medical physics with the request that the survey was completed collaboratively as a single response to ensure accuracy of the data provided. Forty-seven out of 50 centres provided data (Appendix 5). However, three centres completed more than one response, suggesting that the proposed collaboration had not occurred. Each had answered questions on behalf of the other with different responses as to the current position and support requirements for their centre.

Centres were asked to name equipment with IGRT capability, detail its use, the roles and responsibilities of key staff, whether there was an IGRT MPT in place and specifically what support they felt they required.

Additionally, the survey introduction encouraged each centre to identify an IGRT specialist to act as a co-ordinating voice in correspondence with the IGRT support team and also enabled the support team to prioritise visits according to needs indicated in the survey.

3.1 Survey findings (n = 47)

3.1.1 IGRT Equipment Capability

The data provided by respondents made it difficult to establish a clear picture of IGRT capability. Three centres did report that they had had Cone Beam Computed Tomography (CBCT) equipment for up to two years and that it had still not been fully commissioned but there was little detail to support why this was the case.

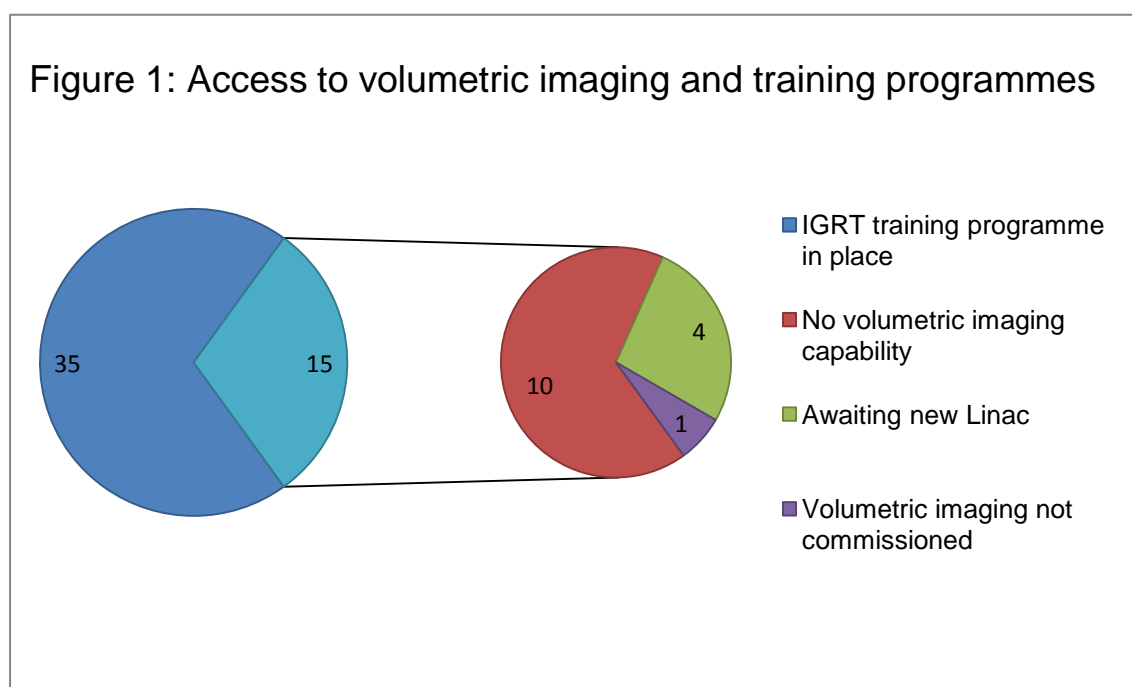
3.1.2 IGRT MPT, Training and Responsibilities

Forty-two centres reported that they had an IGRT MPT in place. Fourteen centres reported that they did not have clearly defined roles and responsibilities for IGRT within their departmental protocols. The absence of an IGRT MPT would seem to explain the absence of clearly defined roles and responsibilities within these centres. Further discussion around this issue following site visits can be found in section 4 of this report.

Forty-three centres had staff that had attended accredited IGRT courses either nationally or internationally, recognising that such training is essential for those that are responsible for both developing and delivering IGRT training in the workplace and implementing IGRT working practices. In some centres these individuals were the IGRT lead radiographer and/or physicist, with others reporting that several staff had attended such courses.

Fifteen centres reported that they did not have a specific IGRT training package in place, six of these being centres that did not have volumetric imaging equipment. It is unclear from this figure whether centres felt that they literally did not have any IGRT training or whether they felt that what they had was not adequate. Ten centres in total responded as having no volumetric imaging capability at the time of the survey with

four of these centres expecting to have CBCT systems commissioned and in clinical use by the end of 2012. The relationship between access to volumetric imaging and the absence of an IGRT training package is highlighted by Figure 1. The larger segment (35) indicates those centres that reported having IGRT training programmes in place; the smaller segment (15) indicates those centres that reported having no IGRT training programme.



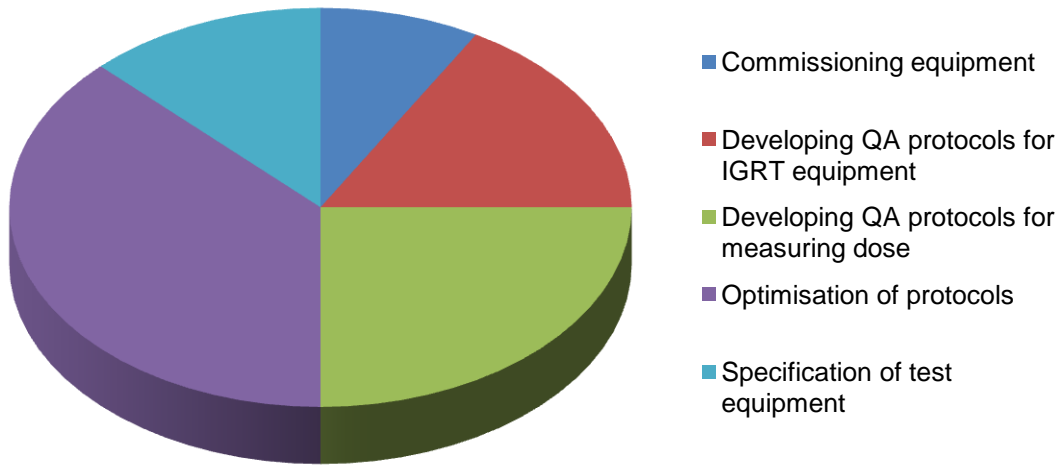
Thirty-six centres responded that they were satisfied with the level of physics applications training and 42 centres were satisfied with the radiographer applications training provided by the manufacturer.

3.1.3 Support

Twenty-one centres responded to say they would like IGRT support from the NCAT IGRT physics team (Appendix 6). Five specific areas of support were requested: commissioning equipment (n=4), developing QA protocols for maintenance of IGRT equipment (n=8), developing QA protocols for measurement of imaging dose (n=12), optimisation of imaging protocols (n=18) and specification of test equipment (n=6). Some centres requested support for each of these areas (Figure 2).

Further analysis of the survey responses indicated that some of these centres were merely seeking an independent review of their practice and felt comfortable with their current IGRT QA programme.

Figure 2: Areas highlighted for physics IGRT support



Specific support requests included IGRT protocol and training documentation review, advice regarding the implementation of IGRT for stereotactic ablative radiotherapy (SABR) and imaging with implanted fiducial markers for prostate radiotherapy.

4. Results from the IGRT review visits and physics IGRT support

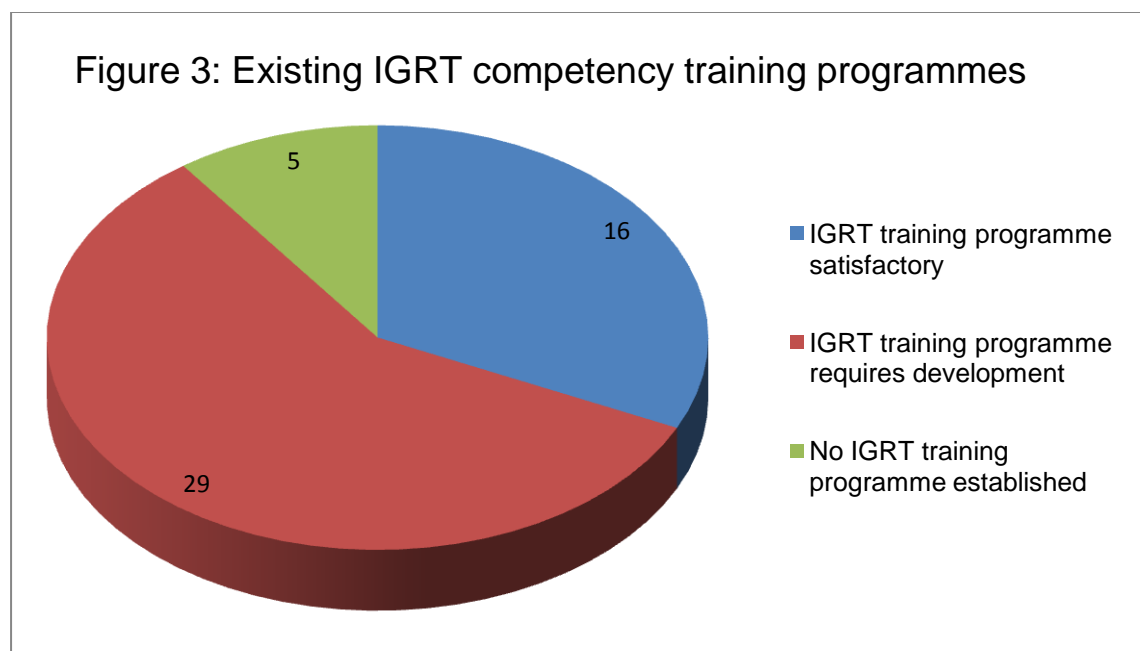
4.1 IGRT review visit results

Each of the 50 NHS radiotherapy centres in England received an IGRT review visit from either one or both of the National IGRT Leads between 1st October 2012 and 30th May 2013 (Appendix 5). During this time 14 centres also received support from the NCAT IGRT physics support teams (Appendix 6).

By the end of the IGRT support programme all 50 centres had an IGRT MPT in place, which was an improvement on the initial survey finding of 42. However, this did not result in much overall improvement in the number of centres found to have clear roles and responsibilities for IGRT embedded within their departmental protocols and work instructions, with 12 of the initial 14 still needing to develop these.

Of the 50 centres that were visited, five did not have an adequate IGRT training programme in place. This result is an improvement on the reported responses from the initial survey. The majority of the remaining 45 centres still require significant development of certain aspects of their training programmes; in particular those that address the analysis and action processes of IGRT. Only 16 centres demonstrated

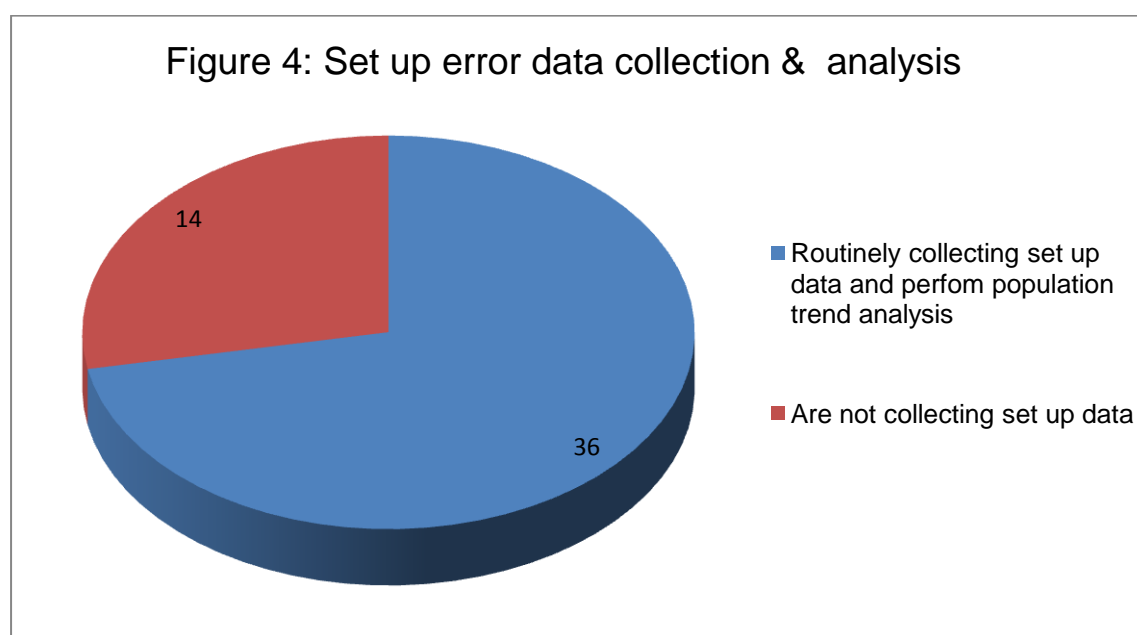
complete training packages that addressed these key processes with adequate competency assessment strategies in place (Figure 3). Many centres only listed a limited number of staff with competence and IR(ME)R entitlement to review and accept image registration. As IGRT increases in use, in order to enable streamlined service delivery, it is essential that the number of staff with competence and IR(ME)R entitlement increase to meet service need. Competency assessment must also be in place to meet this need with subsequent updates of staff training records..



Centres were encouraged to approach the manufacturers for refresher applications training where it was identified that IGRT equipment had not been used clinically for a period of time following installation and commissioning. Image review and training programmes were reviewed in each centre and recommendations made where further development was needed.

Following discussion with members of the MPT during the IGRT review visits and the review of IGRT protocols it was identified that, at the time of writing, 39 centres were both justifying and recording concomitant imaging dose. The majority of the centres that were not recording imaging dose for each patient had measured the imaging dose during the commissioning process and were advised to begin recording this for each patient. Although recording imaging dose is a significant step forward, it is recognised that there is a wide range of practice (eg recording doses as number of scans, as mGy, as mSv, and whether dose is measured in phantom for a “standard” patient or tailored to individual patients). Work is required to achieve standardisation of approach.

The collection and analysis of patient set-up error data was not something that was asked during the initial survey and, as such, a comparison cannot be made. However, it was asked in an earlier NRG IGRT survey conducted in 2011 prior to the publication of the NRG IGRT report.¹ The findings from the IGRT review visits were that 36 centres are now routinely collecting and beginning to perform trend analysis of this data to inform their own local practice (Figure 4) and in the majority of cases there is an MPT approach to this work.



Review of IGRT documentation during the IGRT review visits has highlighted a particular area of weakness in that only 56% (n=28) centres are performing regular risk assessments for IGRT.

4.2 Physics IGRT support results

Twenty one centres responded to the initial survey indicating that they would like to receive support. Following the IGRT lead visits and after follow up from the IGRT physics support team, those that had indicated that support was required through the survey but did not receive it stated that they were satisfied with their current position with regards to IGRT QA. By the end of the support programme, 14 centres had been provided with support from one of the physics support teams which was vendor specific.

The recurring themes for physics support were for validation of existing QA protocols, advice regarding image dose optimisation, data storage for volumetric imaging and the measurement, justification and recording of imaging dose.

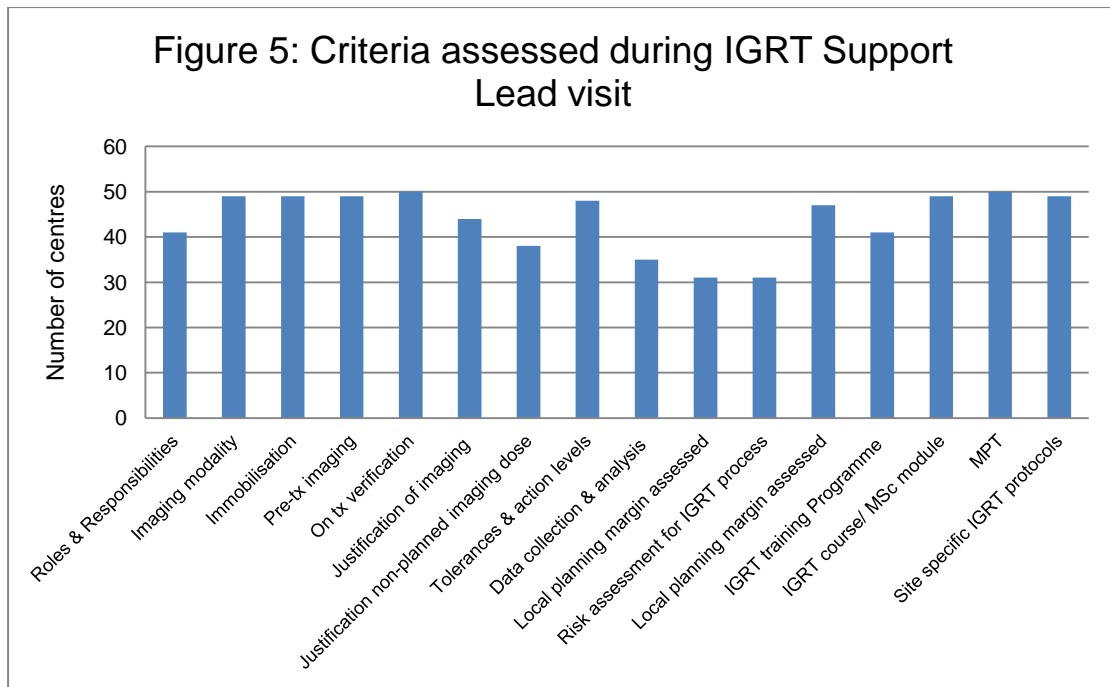
5. Summary of Review Visit Findings

5.1 Compliance with Key Standards for IGRT

Figure 5 illustrates compliance with the 16 criteria selected to measure IGRT implementation across the 50 providers by the end of the programme. Local planning margin (n=31) and risk assessment (n=31) have the lowest compliance. MPT working is seen across all sites however not all define their roles and responsibilities clearly.

A number of support themes emerged during visits, among them the need to define roles and responsibilities within imaging for all professional groups including a vision and strategy for implementing all aspects of imaging developments.

A number of centres did not meet the guidelines laid out within the NRIG IGRT report¹ and 'On target'⁶ and needed support in developing appropriate site specific protocols. These included the clarification of systematic set-up error (SSE) correction terminology; the correct application of the No Action Level (NAL) protocol was frequently misinterpreted and those centres claiming to be using this protocol were, in fact, employing an action level threshold related to their local site-specific patient set up tolerances.



There is limited evidence in the community of recording individual patient imaging doses with some centres using manufacturer pre-set values without local confirmation. Reg 7 3(b) of IRMER requires that an “assessment of patient dose” is undertaken as well as ensuring that dose optimisation takes place. A number of centres requested advice from the physics support teams and the radiographer leads as to where and how imaging dose should be recorded. Further work is required to reach a consensus on this and to rationalise dose recording across pre-treatment and treatment imaging.

Developing local IGRT training programmes is a major priority with some centres sharing their programmes to support development; those creating the required documentation are encouraged to refer to the framework within the guidelines (Appendix 7) and utilise the e-LfH IGRT module.⁴ Centres need to pay particular attention to the image optimisation training provided to radiographers, so that images can be optimised for image analysis purposes. This skill was not widely evident during the IGRT review visits and recommendations were provided to individual centres where this was seen to be an issue. Centres have been encouraged to consider whether the environment in which image review is conducted is optimal.

The findings indicate that there is evidence of good practice and the majority of radiotherapy centres in England are progressing with the adoption and application of IGRT. The collection and analysis of data needs to improve and routine risk assessments should be undertaken.

6. Focus group meeting

A focus group meeting for all of the IGRT Lead therapeutic radiographers and imaging physicists was hosted by the IGRT support team at the end of the support programme in May 2013. This presented an opportunity to feedback the outcomes of the IGRT clinical support programme. All 50 radiotherapy service providers from England were represented at the meeting by at least one member of their IGRT multi professional team. During the meeting, a facilitated workshop was held, the purpose of which was to enable the IGRT support team to gather feedback from the delegates' perspective regarding the success of the support programme. One hundred and four delegates attended the focus group meeting and worked in groups of approximately eight to discuss their experiences under the four headings below.

6.1 Focus group feedback

The quotes below are the responses from the delegates who participated in the facilitated workshop.

6.1.1 Question 1: Did the NRIIG IGRT report change IGRT practice within your centre? If so what change took place?

- "Helped to focus what we need to do and how it should be done"
- "Was utilised in developing documentation"
- "Framed current strategy"
- "Made IGRT a priority topic"
- "Supported business cases for new staff roles"
- "Confidence that underlying principles are sound and affirmed belief that more resources are needed".

In summary, the report has identified IGRT as a priority focus within local implementation strategies.

6.1.2 Question 2: Do you think your IGRT service has changed as a result of the IGRT support programme? If so, how as it changed?

- "Focal point for development within our department"
- "Helped with development of training"
- "Visit was a good audit of imaging practice"
- "Pushed us into going to the next level"
- "Streamlining of processes to increase efficiency"
- "Motivation to reach the end point"
- "Using recommendations to set-up IGRT programme"
- "Initiated analysis of SSE data for local margins"
- "Provided momentum for management to move forward"

- “Good to know we are doing what we could with equipment we have”.

In summary, audit of local practice during the IGRT review visits has enabled centres to streamline their service and focus on areas for development.

6.1.3 Question 3: Thinking about both the IGRT report and support programme

a. What did they do well to support IGRT implementation?

- “Outlined a clear framework to follow”
- “Gave the IGRT team a voice”
- “Good representation of national programmes”
- “1-1 information”
- “Development of training packages”
- “Feedback to management validated work done”
- “Support from team even when don’t have up to date equipment”
- “Team willing to answer questions and share ideas laid out information for training very well”
- “Helped to motivate and focus”.

b. What could they have done better to support IGRT implementation?

- “There is a need for national guidance/ standard”
- “Should be more prescriptive, some departments still doing their own thing”
- “Funding of a rolling programme”
- “Library of protocols”
- “Longer visits to provide training and support”.

In summary, feedback from delegates regarding positive support that they had received included developing training programmes, motivation and focus on IGRT development. An increase in continued support would help to build on the success of the programme.

6.1.4 Question 4: NRAG recommended the implementation of Adaptive Radiotherapy (ART).

a. What are the challenges for your centre now?

- “Resources for implementing new technology”
- “Getting management to understand needs”.

b. What are your plans locally to overcome these challenges?

- “Prioritise limited resources”
- “Appoint specialist in IGRT”
- “Business case for equipment and additional staff”
- “Educate patients to demand advanced techniques”.

c. Is there any further national support which would help?

- “Need penalties for not using imaging”

- “Logs of national equipment and techniques”
- “Library of datasets for training”
- “National group to continue with current work and future development”
- “IGRT sessions in national conferences”.

In summary, to enable ART to be successfully embedded into routine clinical practice, there needs to be more resources made available that include time, staffing and equipment. The implementation of ART must be guided by a national support programme.

6.2 Feedback for radiotherapy equipment manufacturers

Delegates to the focus group were asked to comment on their experience of applications training and any desirable future developments. These are summarised and included within the recommendations in section 8.

Delegates were also asked to put forward a wish list for future IGRT equipment developments that included:

- “Automatic recording imaging dose/exposures/exposure factors/modality for dose reporting units”
- “Remote access for imaging/ patient transfer/off-line review/training/remote terminal access”
- “Access to data for systematic error and population trend analysis, including statistical analysis tools within the oncology management system”
- “Dose overlays / colour washes/ change colour of daily scans”
- “Auto analysis of QA images”
- “Secondary terminals for off-line work / training / image preparation”
- “Reliable CT numbers /CT reconstruction algorithm for accurate Hounsfield Units”
- “Database of calibration data to allow plots of change with time”
- “Post processing software on CBCT for ART”
- “Increase in guidance on QA”
- “AEC for Cone Beam CT optimisation”

7. Conclusion

The individual feedback reports of review visits have assisted radiotherapy centres in England to focus on what is needed to bring IGRT services to the level anticipated by

the NRIIG IGRT report¹ and develop strategies for implementation. Practice is becoming more structured and IGRT is a focal point with increasing status. The training support provided by the IGRT national leads has impacted positively on the development of local practice and streamlining of work processes to increase efficiency. Feedback recommendations have also been a useful tool in assisting service managers with setting objectives for continuing the development of local practice.

The summary of review visit findings demonstrates significant variation in progress towards adoption and implementation of the NRIIG Report¹ recommendations. It sets out those areas that need to develop further, specifically the collection and audit of patient set-up error data, conducting routine risk assessments for IGRT and the development of robust IGRT training packages.

The recommendations have been developed for all stakeholders and represent current best practice identified through the clinical support programme which, if implemented, will ensure that patient outcomes will continue to improve as IGRT enables 4D ART to become embedded in clinical practice.

8. Recommendations

8.1 Radiotherapy service providers

Recommendations were presented to centres after the visit within a formal report; criteria were measured in each centre and the gap between actual and desired assessed.

8.1.1 Environment

- The design of treatment control areas need to be reviewed so that lighting levels can be adjusted to optimise contrast within the image. Minimising interruptions and distractions in these areas is essential.

8.1.2 MPTs

- IGRT MPTs must ensure there is an IGRT strategy to support future developments.
- Multi-professional working must be enhanced and skills used appropriately, including developing radiographer-led image review.

- There needs to be collaboration between the MPT's during linear accelerator and CT scanner replacement. There is potential for the development of novel roles in commissioning.
- A scope of practice for the advanced imaging radiographer role should be created to define and justify the responsibilities of this role.
- Risk assessments must be completed when implementing new technology and techniques. This is made clear in the NRIIG IGRT report.¹

8.1.3 Protocols

- The roles and responsibilities within clinical and local IRMER protocols need to be accurate and reflect updated IGRT training and entitlement to act in IRMER roles. Protocols must be reviewed for those individuals justifying non-planned imaging dose to ensure they are in-line with IR(ME)R Legislation and guidance.^{2,3}
- The use of document templates is recommended to ensure continuity in the format of local protocols and work instructions.

8.1.4 Training

- All providers to have access to and use the e-LfH IGRT module⁴ as part of local training and competency programmes.
- Training workbooks for MV/kV planar imaging and 3D volumetric imaging are desirable. Training records for IGRT under IRMER must be updated too. There are key components: these should include;
 - Mandatory reading of policy documents and work instructions/protocols.
 - Educational component to include equipment functionality, image quality and image artefacts, dosimetry teaching regarding contour change and anatomical anomalies, evaluation of image review accuracy and CT anatomy interpretation testing.
- Investigate strategies for expediting IGRT training as a stop gap that may include training out of clinical hours or during machine service time.
- A database of interesting patient cases that can be used as a training aid to help assess troubleshooting skills should be compiled.
- Developments in applications training must be driven by service providers and reflect local pathway requirements (also see 8.5 below).
- Protected time needs to be provided for the IGRT team including the lead imaging radiographers, clinical radiographers and physicists to enable the

development and implementation of IGRT training programmes as recommended in the NRIIG IGRT report.¹

- Introduce a simple competency based training matrix.

8.1.5 Imaging doses

- IRMER requires that an assessment of patient dose is undertaken. Imaging doses should be recorded for each patient as a total concomitant exposure received during planning and treatment (Regulation 7, 3(b) of IRMER).
- Further work is required to ensure consistency in approach between pre-treatment and treatment imaging and between centres. It is suggested this may be a role for the IPEM interdepartmental audit group.

8.1.6 Equipment

- The commissioning of all imaging equipment should be completed to enable image-guided intensity modulated radiotherapy (IG-IMRT) to be utilised effectively while reducing appointment times.

8.1.7 Imaging

- Image review must become competency and not grade-based as this will enable a more efficient and flexible service.

8.1.8 Audit

- Consider the introduction of regular audit of intra and inter user variability in image matching.
- Audit of patient set up error data must become routine practice to help inform local planning margins and justify on-treatment image verification frequency.

8.2 NHS England Specialised Commissioning

- Clearer guidance for IGRT tariffs is required, in particular that which relates to the use of the 'Adaptive' code Y91.4.
- A new code is required for IGRT linked to levels of complexity as outlined in the NRIIG IGRT report.¹
- Future guidance relating to IGRT coding needs to be less ambiguous to avoid misinterpretation and to ensure its application is standardised.

- The IGRT Commissioning for Quality and Innovation (CQUIN) would benefit from being reviewed so that it becomes more prescriptive allowing it to be interpreted consistently by all service providers.

8.3 Radiotherapy education providers

- Radiotherapy service providers must work with local Higher Education Institutions in developing the minimum requirements to enable new radiographers to be fit for purpose as outlined in the Education and Career Framework.⁵
- Volumetric image analysis and decision making skills need to be developed during undergraduate and post graduate pre-registration programmes via a standardised IGRT curriculum.
- All education providers are advised to adopt the IGRT training framework outlined in Appendix 7.

8.4 Radiotherapy board (Joint professional bodies: SCoR, IPeM, RCR)

- It is essential that the professional bodies continue to work together to support the work that had been funded by NCAT, so as not to lose the momentum of change that has been established.
- A follow-up survey to assess the progress that has been achieved with regards to IGRT implementation is advisable after 12 months.
- There is an appetite for improved physics IGRT support and physicists are encouraged to utilise the medical-physics-engineering@jiscmail.ac.uk listserver and RT imaging SIG 'Google' forum established by the SCoR.

8.5 Radiotherapy equipment manufacturers

- Applications support needs to include anonymised data sets or possible access to on-line web demonstrations (modular e-learning) for group learning and discussion of non-standard cases for training, reducing the use of phantoms.
- Follow-up visits or annual training updates.
- Remote terminal access for off-line review and IGRT training.
- Access to data for systematic error and population trend analysis, including statistical analysis tools must be made available.
- More in depth training regarding registration algorithms and training in image analysis and QA was requested by physicists.

8.6 Radiotherapy trials

- The IGRT component of any trial methodology must be clear and work must continue with the RTTQA group in developing an accreditation method for IGRT that is anatomically site-specific.

National IGRT Team

9. References

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Appendix 1 - Key standards for IGRT

Protocols
Are individual roles and responsibilities clearly defined between the multi-professional groups?
Equipment used (Imaging modality)
Immobilisation
Pre-treatment imaging
On treatment verification imaging modality
Justification of imaging frequency
Justification of any non-planned imaging dose
Tolerances and action levels
Data collection methods and analysis of data. Local planning margin assessment strategy
Risk assessment for IGRT process
Training and Responsibilities
IGRT Radiographer in post
IGRT training Programme
Attended accredited IGRT course or MSc Module
Implementation of IGRT
IGRT MPT in place
Site-specific IGRT protocols

Appendix 2 - Levels of IGRT complexity¹

	Level	Goal	Imaging Technique	Imaging frequency	Correction strategy (or comment)
RT planning (for localisation of target volumes & OAR's)	0a	Reduce uncertainty in defining target	Planning CT	Once only	Definition of Physical targets and Organs at Risk (OAR's)
	0b	Reduce uncertainty in defining target	Planning CT + use of contrast agent	Once only	Improves definition of physical targets and OAR's
	0c	Reduce uncertainty in defining target	Planning CT + MRI or PET	Once only	Improves definition of physical targets and OAR's and defines functional targets and OAR's
	0d	Reduce uncertainty in defining target	4D planning CT or multiple CT's prior to treatment to determine patient specific variations in anatomies	Once only (4DCT) or multiple CTs	Physiological target and OAR's defined by combining GTV's from all phases or scans

	Level	Goal	Imaging Technique	Imaging frequency	Correction strategy (or comment)
Treatment (comparing surrogate anatomy)	1a	Reduce gross setup error	Analyse using bony anatomy	First fraction only	Online: Correct gross error
	1b	Reduce initial systematic setup error	Analyse using bony anatomy	First 3-5 fractions and weekly	Offline: 1 st 3-5 # Calculate and correct systematic error * Weekly- check within threshold
	1c	Continuous reduction of systematic error	Analyse using bony anatomy	First 3-5 fractions and weekly	Offline: 1 st 3-5# Calculate and correct systematic error* Weekly- re-calculate and correct systematic error
	1d	Reduce random and systematic error	Analyse using bony anatomy	Daily or less	Online : if <daily then calculate and correct systematic errors*
	1e	Reduce uncertainty from anatomy changing trends	Analyse using bony anatomy and/or visual check/quantitative check of set up parameters	Weekly or more frequently	Off line: Consider intervention

	Level	Goal	Imaging Technique	Imaging frequency	Correction strategy (or comment)
Treatment (comparing target anatomy)	2a	Reduce gross setup error	Analyse using target anatomy or implanted markers	First fraction only	Online: Correct gross error
	2b	Reduce initial systematic error	Analyse using target anatomy or implanted markers	First 3-5 fractions and weekly	Offline: 1 st 3-5# Calculate and correct Systematic error* Weekly- check within tolerance
	2c	Continuous reduction of systematic error	Analyse using target anatomy or implanted markers	First 3-5 fractions and weekly	Offline: 1 st 3-5# Calculate and correct systematic error Weekly- re-calculate and correct systematic error
	2d	Reduce random and systematic error	Analyse using target anatomy or implanted markers	Daily	Online: daily imaging ideally throughout treatment course**
	2e	Reduce uncertainty from gross anatomy changes of target or OAR	Analyse using target anatomy or implanted markers	Weekly or more frequently	Online or offline: Consider intervention

	Level	Goal	Imaging Technique	Imaging frequency	Correction strategy (or comment)
Treatment (correct intrafractional error)	3a	Reduce intra-fraction errors	Online analysis using tracking (repeated imaging during delivery)	Real time or periodic intermittent imaging (can be in conj. with any other imaging freq.)	Online: Interrupt treatment during delivery and correct errors greater than action level
	3b	Reduce uncertainty from physiological movements (i.e. respiratory)	Online analysis using automatically gated imaging system (delivered only when target within treatable position)	Real time monitoring	Online: System automatically gated to deliver only when tumour is within treatable position (following action level).
	3c	Reduce uncertainty from physiological movements (i.e. respiratory) and automatically correct	Automatic online detection and analysis of target position	Real time monitoring	Online: System configured to change the treatment field to track the tumour.

	Level	Goal	Imaging Technique	Imaging frequency	Correction strategy (or comment)
Adaptive RT	4a	Reduce uncertainties from shape change (pre-scheduled repeat planning CT)	Schedule repeat planning imaging during treatment course. Offline dosimetric assessment	Once to weekly	Re-plan when dosimetric action level exceeded
	4b	Reduce uncertainties from shape change	Treatment unit imaging & online or offline dosimetric analysis (identifying changes in probable tumour coverage from shape change)	As seen	Re-plan to assess for dosimetric changes. Implement changes
	4c	Reduce uncertainties from shape change (pre-planned treatment imaging assessments)	Treatment unit imaging & online or offline geometric analysis Compare plan database for best fit (for that fraction)	Each fraction	Deliver 'plan-of-the-day' for that fraction
	4d	Reduce uncertainties from shape change (react throughout treatment imaging session)	Treatment unit imaging & online dosimetric analysis	Each fraction	Real-time (4D) ART

Appendix 3 - Agenda pro-forma

Proposed Agenda for a one day support visit

9:30 - 10:15	Meet with IGRT MPT to agree the focus for the support
10:15 - 10:45	Tour of the department
10:45 - 12:00	Observation of IGRT on the treatment units (2D & 3D where possible)
12:00 - 14:00	Lunch and deliver presentation to staff (PPT 30 mins; delivered twice)
14:00 - 15:00	Review of training docs / protocols
15:00 - 15:30	Time to answer any physics queries (Physics support is provided remotely by the NCAT physics support team via IGRTsupport@ncat.nhs.uk)
15:30 - 16:00	Further discussion as required with MPT
16:00 – 16:15	Provide headline feedback to IGRT MPT

Appendix 4 - National IGRT Lead - IGRT review visit report

National IGRT Lead - IGRT review visit report

1. Centre information

Name of centre	Name of NHS Trust
Head of Radiotherapy	Head of Medical Physics

IGRT lead responsible for review	Date when request for support received
Choose an item.	Click here to enter a date.
Date visit commenced	Number of days for visit
Click here to enter a date.	Choose an item.

2. Support request details

List the areas of support requested by the centre

3. IGRT multi-professional team

At the start of the visit, was there an IGRT MPT in place?

Choose an item.

Comments about the MPT

4. Protocol review

Protocol contents	Yes	No
Are individual roles and responsibilities clearly defined between the multi-professional groups?	<input type="checkbox"/>	<input type="checkbox"/>
Equipment used (imaging modality)	<input type="checkbox"/>	<input type="checkbox"/>
Immobilisation	<input type="checkbox"/>	<input type="checkbox"/>
Pre-treatment imaging	<input type="checkbox"/>	<input type="checkbox"/>
On treatment verification imaging modality	<input type="checkbox"/>	<input type="checkbox"/>
Justification of imaging frequency	<input type="checkbox"/>	<input type="checkbox"/>
Justification of any non-planned concomitant exposure	<input type="checkbox"/>	<input type="checkbox"/>
Tolerances & action levels (<i>details of correction strategies</i>)	<input type="checkbox"/>	<input type="checkbox"/>
Data collection methods and analysis of data	<input type="checkbox"/>	<input type="checkbox"/>
Local planning margin assessment strategy	<input type="checkbox"/>	<input type="checkbox"/>
Risk assessment for IGRT process	<input type="checkbox"/>	<input type="checkbox"/>

Summary of findings from protocol review

5. Training

- Have members of the MPT attended accredited IGRT educational courses or do they possess suitable experience to enable them to lead development of the service? Yes, but not all
- Do the physicists have specific IGRT training and competency assessments? Yes
- Do the radiographers have specific IGRT training and competency assessments? Yes
- Is there evidence that an IGRT training programme has been established? Yes, needs development

Where it exists, outline the IGRT training programme currently employed within the centre

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6. Physics support

- Did the centre request support from the IGRT physics support team? Choose an item.
- Did the IGRT lead refer the centre to the physics support team? Choose an item.

Summary of the physics support provided to the centre (*feedback to be provided by the IGRT physics support team*)

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7. Overall findings

Environment
Therapeutic Radiographers
Radiotherapy Physics
Protocols
Training

8. Recommendations

Action plan provided during headline feedback must be include as an appendix to this report

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9. Report approval

Report completed by:	Choose an item.	Date:	Click here to enter a date.
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Appendix 5 - Date of scheduled National IGRT Lead review visits and responses to the IGRT survey

Centre Name	Date of scheduled visit	Responded to survey	Centre Name	Date of scheduled visit	Responded to survey
Mount Vernon	01/10/2012	Y	Wolverhampton	30/01/2013	Y
Manchester	18/10/2012	Y	Leicester	06/02/2013	Y
Coventry	24/10/2012	Y	Southend	07/02/2013	Y
North Middlesex	29/10/2012	Y	Brighton	12/02/2013	Y
Barts	06/11/2012	Y	Norwich	15/02/2013	Y
Devon & Exeter	07/11/2012	Y	Cambridge	19/02/2013	Y
Taunton	09/11/2012	Y	Queens, Romford	20/02/2013	Y
Royal Marsden	09/11/2012	Y	Newcastle	21/02/2013	Y
Northampton	13/11/2012	Y	University College	25/02/2013	Y
Reading	15/11/2012	Y	Hull	25/02/2013	Y
Plymouth	20/11/2012	Y	Preston	28/02/2013	Y
Bath	20/11/2012	Y	Clatterbridge	07/03/2013	Y
Truro (Royal Cornwall)	21/11/2012	Y	Carlisle (Cumbria Uni)	12/03/2013	Y
Sheffield	26/11/2012	Y	Colchester	19/03/2013	Y
North Staffordshire	04/12/2012	Y	Shrewsbury	10/04/2013	N
Southampton	05/12/2012	Y	Lincoln	11/04/2013	Y
Guildford	06/12/2012	Y	Sheffield (2 nd)	16/04/2013	Y
Oxford	06/12/2012	Y	Birmingham	16/04/2013	N
Kent	10/12/2012	Y	Middlesbrough	18/04/2013	Y
Peterborough	11/12/2012	Y	Derby	23/04/2013	Y
Imperial	12/12/2012	Y	Poole (2 nd)	26/04/2013	Y
Royal Free	08/01/2013	Y	Nottingham	01/05/2013	Y
Ipswich	09/01/2013	Y	Bristol (2 nd)	09/05/2013	Y
Guy's & St Thomas'	10/01/2013	N	North Middlesex (2 nd)	15/05/2013	Y
Bristol	18/01/2013	Y	Gloucs & Cheltenham	30/05/2013	Y
Portsmouth	21/01/2013	Y			
Leeds	28/01/2013	Y			
Poole	29/01/2013	Y			
Torbay (South Devon)	30/01/2013	Y			

Appendix 6 - Provision of physics IGRT support

Centres that indicated support required through the IGRT survey	Centres that received support from the physics IGRT support teams as recommended during the visit
Bath	Birmingham
Barts	Coventry
Bristol	Imperial (Charing Cross)
Cheltenham	Ipswich
Coventry	Maidstone
Devon & Exeter	Norwich
Hull	Oxford
Mount Vernon	Plymouth
North Middlesex	Poole
Norwich	Portsmouth
Oxford	Reading
Plymouth	Sheffield
Poole	Southampton
Portsmouth	Taunton
Preston	
Reading	
Sheffield	
Shrewsbury	
Southampton	
Torbay	
Truro (Royal Cornwall)	

Appendix 7 - IGRT Training Programme Framework¹

The IGRT training programme should cover 3 aspects

Acquisition process – this could be covered in a formal presentation either delivered face to face or electronically. This should be accompanied by appropriate written documents which could be followed when practicing using a phantom. Issues relating to imaging dose and quality should also be included

Analysis process – cover in presentation and written instructions. A database of patient images for all IGRT techniques and anatomical sites should be available for practice

Action - guidance for the timing and frequency of actions with explanation of the site specific protocols

Assessment

Assessment can be a combination of self-assessment and peer assessment. For example workbooks could be used to explain each IGRT technology system and the applications with self-assessment of baseline skills and further reading to develop greater understanding. The workbooks, ideally to be developed by the core site specialist multi-professional group, could be general eg use of kV CBCT or site specific for complex cases eg adaptive bladder, stereotactic lung. Competency assessments using a database of images to match against a standard can then also be used with a predetermined threshold for acceptable clinical competence.

Suggested contents of a workbook:

Departmental work instructions

Relevant journal articles for use of the technique for that anatomical site

CT Anatomy (and test).

The use of VERT should be considered and utilised as appropriate. Otherwise a treatment planning system may be used where the GTV, OAR would be pre-outlined for reference. The trainee could contour the structures with the reference contours turned off and then compare.

Detail of staging, epidemiology/aetiology, current management and treatment options

Relevant clinical trials for this anatomical site

Assessment of competency which could include:-

- (i) Self-assessment of baseline skills with questions to verify learning
- (ii) Record of image analysis registrations
- (iii) Specific learning objectives
- (iv) Portfolio of relevant experience
- (v) Evidence of observation of registration/action

A competency assessment program should not only assess image analysis skills but also the decision making process for appropriate action. This may require additional training for example DVH interpretation, IMRT/VMAT implications for image guidance as well as individual cases where anatomy anomalies may affect the action.

Regular updates should be mandated, the frequency of which will depend on departmental rotation time, the number of IGRT capable linacs and sites treated on each linacs. Ideally annual updates are recommended together with re-assessment of competence after a period away from the specific technology.