

Radiotherapy target volume definition and peer review, second edition

RCR guidance

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Contents

Summary and minimum standard	3
1 Introduction	4
2 Patient preparation for radiotherapy	9
3 Radiotherapy protocols	9
4 Practical aspects of volume definition	10
5 Defining target volumes	11
6 Which contours should be peer reviewed?	15
7 Peer review meetings and documentation	16
8 Education and continuing professional development (CPD)	19
Appendix 1	
Examples of protocol-specified and individualised volumes	24
Appendix 2	
Sample contouring labels	25
Appendix 3	
Examples of peer review meetings in UK departments	26
Appendix 4	
Individual case examples of peer review	29
Appendix 5	
Suggested peer review outcome record template	32
Appendix 6	
Definitions of major and minor changes recommended at peer review	34
Appendix 7	
Examples of major and minor changes found at peer review	35
Appendix 8	
Example risk assessment for 'single point of failure' clinical oncologists	37
Appendix 9	
Other useful resources	39

Summary and minimum standard

Recommendations

1. Radiotherapy target volume (TV) contours should be subject to systematic review by appropriately trained and experienced peer professionals. All radiotherapy departments should have clearly defined processes that enable optimal TV delineation and subsequent peer review. All radiotherapy departments should adopt a standardised peer review meeting structure with these meetings recorded against nationally agreed minimum dataset requirements.
2. Target volume guidelines should be specified in protocols which should be standardised across a clinical network or ideally nationally or internationally.
3. The American Association of Physicists in Medicine (AAPM) – Task Group (TG-263) nomenclature should be used to label TVs and organs at risk (OAR). Consistent colours should be used for volumes within each department.
4. Professionals involved in contouring should have protected time in their job plans for TV definition and for peer review of TVs. No other tasks should be booked simultaneously. The amount of time required will vary depending on tumour sites and complexity. Hospitals are responsible for providing adequate time in clinicians' job plans to enable peer review without delaying treatment pathways.
5. Hospitals should provide consultants with an appropriate working environment, including information technology (IT) infrastructure, to facilitate TV definition.
6. Prospective peer review of contours should occur in cases where considerable individual judgement is required. Where major changes have then been recommended at initial peer review, the final contours should be reviewed again before submission. In all other situations, a proportion of contours should be quality assured retrospectively. Departmental recommendations for either prospective or retrospective peer review should be protocolised and guided by published evidence where available.
7. Hospitals and Cancer Alliances should facilitate peer review between departments by investing in appropriate IT infrastructure and information governance.
8. Each department should have an agreed process for peer review of TVs. The frequency and nature of peer review should be specified for each tumour site depending on the complexity of the volumes and should be reviewed periodically to ensure sufficient time for discussion of cases. Departmental process documents for peer review should also specify the necessary and desired attendees.
9. A planning note should be written for each radiotherapy course explaining how and why TVs were defined, with reference to protocols as necessary.
10. Departments should use a standardised peer review outcome record template. This will facilitate audit of their processes in relation to quality assurance (QA), peer review of TVs, review of amendments in TVs after peer review and review of radiotherapy treatment plans. Such audits should form part of each radiotherapy departments' annual audit programme.
11. Departments should audit radiotherapy outcomes in terms of loco-regional control and toxicity and should therefore be able to use such data to better inform TV definition in the future.
12. Clinical oncologists should be able to evidence high quality contouring and engagement in QA of TVs as part of annual appraisal.

1 Introduction

Purpose of the guidelines

Radiotherapy TV delineation is a key part of the chain of tasks from consenting a patient for radiotherapy to treatment delivery.^{1,2} The site known to have cancer and the areas at risk of tumour spread are defined on a series of cross-sectional images on a computer to create a 3-dimensional volume, and in some areas a 4-dimensional volume, of part of the body to which a treatment dose of radiotherapy can be applied. The use of all available imaging technologies should inform radiotherapy TVs. Incorrectly outlining the area at risk means that areas of cancer may be undertreated, reducing the chance of cure. However, treating too large a volume increases the volume of normal tissue that is treated and increases the risk of side-effects. There are also specific structures or organs that must be identified and avoided in radiotherapy planning to minimise the risk of damage.

Target volume definition requires an assessment of clinical information and imaging to know the location of the tumour (or tumour bed in the case of adjuvant treatment), an understanding of the possible routes of microscopic spread and an appreciation of potential positional errors. The uncertainties involved in this complex decision-making process mean that the oncologist must use judgement to consider the potential benefits and possible harms of treatment for each individual case. Wherever complex human judgements are made there is the potential for variability, bias and error.

The Royal College of Radiologists (RCR) Clinical Oncology Professional Support and Standards Board has commissioned this second edition of these guidelines to support oncologists to make better contouring decisions, in the light of the latest evidence. These updated guidelines define minimum standards for volume definition and for peer review of contours, and recommend a more structured, auditable process for recording the peer review process. Building on work in the UK, Canada, Australia and the USA, these guidelines set out how UK clinical oncologists should best define TVs, which treatments may benefit most from peer review and how and when peer review of TVs should be performed and recorded.^{3,4,5,6,7,8,9,10,11,12} The guidelines offer examples of good practice and provide tools to help implement peer review in a department.

While these guidelines are written as though a consultant clinical oncologist is defining the volumes and providing peer review (the 'operator' in the Ionising Radiation [Medical Exposure] Regulations [IR[ME]R] terms), other competent specialists may also perform these tasks, for example radiographers, radiologists, dosimetrists, physicists or senior oncology trainees. Indeed, such cross-disciplinary working is to be encouraged and should be assumed throughout this document. Other specialists acting as operators should be able to demonstrate the same level of competence as consultant oncologists, measured to the same standards.

The guidelines are written to be relevant for external beam photon radiotherapy (EBRT), but there are elements of the processes of volume delineation and peer review that could also apply to brachytherapy or superficial therapy. These techniques are not specifically covered here.

Variation in contouring

The purpose of peer review is not to eliminate variation completely – this is neither possible nor desirable because TV definition involves judgement around many different variables: there is not a universally accepted TV for a given tumour and there is no test that can prove that a volume is absolutely correct.¹³ However, from studies in many different cancer

types, the magnitude of inter-individual variation in contouring is known to be substantial.¹⁴ Variation in TV delineation may lead to overly large volumes which risk an increase in normal tissue toxicity, or volumes that are too small and can lead to a geographic miss and/or failure to control disease. Variation in contouring of OAR may also lead to incorrect assumptions about the risk of damage to those organs. Variation may be categorised as acceptable or unacceptable. Causes of variation include lack of expertise/training, absence of a clear protocol or cognitive bias. Reducing variation and increasing standardisation between individuals and departments has been effective in improving quality in many areas of medicine.^{15,16} Errors have been described in other specialties where clinical judgement is used – for example, in pathology and diagnostic radiology.^{17,18} Reducing variation is highly likely to be the correct approach in a scenario as complex as radiotherapy treatment planning.

Protocols can provide a peer-defined standard for all aspects of treatment, including contouring.¹⁹ However, protocols cannot always describe the variation in normal and pathological anatomy between individual patients. Existing tools, including online contouring atlases, clinical trial participation and real-time workshops, aim to reduce variability through education. But even the judgement of experts (being themselves human with cognitive biases and not immune to making errors) can be imperfect. In addition to education and training, QA is required to increase standardisation of practice and to reduce the risk of error.

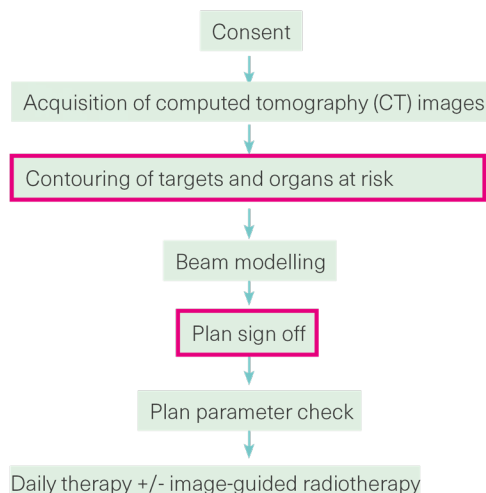
Unlike other steps in the radiotherapy planning process, volume definition is not always independently verified or quality assured outside of clinical trials. Historically one clinical oncologist working alone has usually defined the TVs, and additional formal checking processes were not part of standard practice until the first edition of this guidance, albeit this guidance has not been universally implemented. There is increasing evidence that incorrect volume definition can directly affect clinical outcomes and that a systematic approach to volume definition, including peer review by colleagues, can produce more consistent and accurate volumes.^{20,21,22,23}

Since the first edition of this guidance there have been developments in artificial intelligence (AI)-based applications for radiotherapy. Commercial and academic autosegmentation tools are increasingly available, mainly for OAR contouring of several different body sites.²⁴ The majority of commercial solutions to date have used atlas-based contouring, in which deformable registration is used to directly propagate contours from a library of previous cases. Edited atlas-based contours have been shown to improve consistency in contours and dose distribution in the head and neck compared to manual contours.²⁵

Quality assurance in radiotherapy

The 2008 RCR document *Towards Safer Radiotherapy* has helped establish a culture in UK radiotherapy of QA, error detection and reporting.²⁶ Error detection relies on a systematic way of working in which checking processes find incidents and enable their correction before they have a clinical effect. In the parts of the process where checks are undertaken, the number of radiotherapy errors which are reported to cause direct harm to patients is very small.

Figure 1. Example of workflow for radiotherapy planning and delivery. Red boxes indicate parts of the pathway that are not always checked.



When radiotherapy errors occur, they can be devastating for patients and costly for the NHS. Radiotherapy contours are stored electronically and can be audited after the treatment has finished. Any errors that were not corrected could therefore leave both the oncologist and the NHS trust/Health Board liable to litigation. Steps to improve radiotherapy quality, accuracy and safety are entirely consistent with an improving safety culture, which is integral to the vision of the NHS throughout the UK.²⁷

QA of contouring has become a standard part of most radiotherapy clinical trials, as it is now known that protocol non-compliance can lead to adverse outcomes.^{20,21,28,29,30} Most trials now produce a detailed radiotherapy protocol which explains how contours are to be defined, often with the addition of worked examples and atlases.

There are usually two parts to the clinical trial radiotherapy QA process. In pre-accrual QA, potential investigators must satisfactorily undertake an outlining benchmark exercise where their contours are compared to an agreed reference standard with qualitative feedback before they can participate in the trial. During accrual QA involves individual case review, where the contours are reviewed, generally by a member of the trial management group, with reference to diagnostic information, either prospectively before the patient starts treatment or retrospectively. This retrospective review may either be after the patient has finished treatment or timely retrospective where review takes place with enough time to during the patient's treatment if an unacceptable variation is identified. The burden of QA for each trial should be proportional to the complexity or risk of the trial (for example, a greater level of QA required for a new indication for radiotherapy in a particular tumour site, a new radiotherapy technique or where there is dose escalation or de-escalation). Clinical trials teams have therefore developed a methodology for peer review that could be adapted for use for patients treated outside trials.³¹

The case for colleague peer review of volumes

Peer review of TVs is the concept of a formal review of the delineated contours by another site-specific oncologist. Reviewing TVs should be undertaken alongside a review of dose and fractionation. OAR contouring should undergo the same robust checking process, with

appropriate QA processes, particularly for OARs that are more difficult to define. Review should ideally occur before therapy begins to allow corrections to be made if needed, and for complex cases, prior to physics/dosimetry input to avoid the need for re-planning. Different models for peer review have been described depending on tumour site, number of physicians involved and the logistics of job planning and IT.^{5,7,8,9,11}

A meta-analysis of peer review reports that 11% of treatment plans are changed after peer review, a proportion of which will directly affect patient outcomes.³² In some studies, and particularly in tumour sites where volume definition is more complex, peer review recommends changes in a much higher proportion of contours. Even in tumour sites where clear protocols exist to describe treatments (for example, field-based planning for breast cancer) peer review is demonstrated to change practice.⁸ There is no evidence that experienced oncologists do not also benefit from peer review. The number of changes recommended by a peer review programme may reduce with time as delineation conformity improves.³³

While aiding complex decision-making, reducing variation and detecting occasional random errors are the main measurable benefits of peer review, there are other benefits to physicians and departments and therefore to patients. A peer review process fosters a culture of transparency, quality and safety, and encourages knowledge-sharing and teaching. Ensuring that oncologists work in teams makes cross-cover arrangements safer. Regular meetings provide space for oncologists to reflect on a very complex part of their practice and help them to be more confident that TVs have been defined optimally. There is also the added benefit of peer review in education and training.³⁴

Although peer review will require time from the participants, an effective peer review process may add efficiencies elsewhere in the radiotherapy pathway. For example, as physician confidence that the correct contours are being drawn first time increases, contours may be completed faster as well as more accurately. Peer review of contours before a plan has been created will reduce the need for re-planning.

The Canadian Partnership for Quality Radiotherapy has championed peer review and made peer review of all curative treatments a standard, ensuring it is part of routine care in many Canadian centres.³⁵ A 2016 survey of UK heads of service elicited strong support for peer review but found understandable concerns about how to find the time to embed it into routine clinical practice.

The anticipated benefits of peer review of radiotherapy target volumes include:

- Setting and maintaining standards within centres and nationally
- Providing peer support for difficult decision-making in contouring
- Reducing inter-individual variation in contouring
- Promoting a culture of quality, safety and transparency
- Improving communication with the rest of the radiotherapy planning team
- Improving training for clinical oncology trainees, radiographers, dosimetrists and physics students
- Detecting major discrepancies (errors) which require a clinically significant change to the target volumes
- Ensuring patients have confidence in the QA of the whole radiotherapy process.

Challenges and resource implications

The human resource implications of implementing this guidance should not be underestimated in a specialty where consultant capacity is already stretched by the continually increasing demand for, and complexity of, oncological treatments. However, without optimising this aspect of the planning process it is not possible to be assured that radiotherapy targets are being defined with the required accuracy. Therefore, routine QA by peer review of volumes is a core service requirement for radiotherapy services and should be included in consultant clinical oncology job plans and supported by operational delivery networks (ODNs).³⁶ Employers have a duty to support such QA as part of their role as defined by IR(ME)R. Consultants and service leads should think about how best to align job plans of those with the same site-specific expertise within and sometimes between trusts.

For many departments, another challenge of introducing peer review will be avoidance of delay in the overall patient pathway. This will necessitate collaborative multidisciplinary teamworking to streamline the 'events' in the patient pathway prior to radiotherapy treatment and will require individual departments and teams to consider whether to conduct peer review meetings at regular fixed times or 'on demand'.

Effective and efficient contouring and peer review depends on an optimal working environment and IT infrastructure³⁷. Trusts and radiotherapy partnerships should assess whether their current hardware and software for contouring and peer review are fit for purpose and make plans to upgrade these where necessary.

Peer review should be a supportive process that is mutually beneficial for all participants. Individuals should never feel threatened by the process and colleagues should work together constructively at all levels of experience. There is also the possibility that peer review could become a box-ticking exercise or that review could endorse suboptimal treatment if all participants are making the same errors (a false consensus cognitive bias). Peer review could even introduce errors if all the relevant information, including reasons why contours have defined as they have been, is not available at the review. Peer review outcomes should therefore be monitored and audited to ensure that all those involved – and especially patients – are deriving as much benefit as possible. For these reasons, these updated guidelines additionally recommend that radiotherapy departments adopt a standardised peer review meeting structure (whether ad hoc meetings or at a regular time) and that such meetings follow nationally agreed minimum dataset requirements for the reporting of peer review outcomes (See Appendix 3).

Recommendation 1:

Radiotherapy target volume contours should be subject to systematic review by appropriately trained and experienced peer professionals.

All radiotherapy departments should have clearly defined processes that enable optimal target volume delineation and subsequent peer review.

All radiotherapy departments should adopt a standardised peer review meeting structure with these meetings recorded against nationally agreed minimum dataset requirements.

2 Patient preparation for radiotherapy

A healthcare professional with appropriate competencies can refer a patient for radiotherapy. Radiotherapy must be justified by an oncologist or radiographer with appropriate training in radiation oncology (IR[ME]R).

Decisions around radiotherapy should consider the preferences of the patient and their desired level of involvement in the process. A shared decision-making approach between patient and clinical team will include the provision of adequate verbal and written information to enable the patient and, where appropriate, their carer(s), to understand the potential benefits and risks of radiotherapy and to understand the alternative options which might be considered. Consent is a fundamental legal and ethical principle. All patients have the right to be involved in decisions about their treatment and care and to make informed decisions if they can. The exchange of information between doctor and patient is essential to good decision-making. Serious harm can result if patients are not listened to, or if they are not given the information they need – and time and support to understand it – so they can make informed decisions about their care. Doctors must be satisfied that they have a patient's consent or other valid authority before providing treatment or care.

The process of informed consent should be undertaken with the patient by a professional with appropriate competency to explain in detail the aims and the expected frequent, infrequent and serious side-effects of treatment, both acute and late.³⁸ Sufficient time should be allowed between the provision of information and formal documentation of consent to allow the patient to absorb and understand the information and to reflect on it and discuss with others if they so wish. Consent should be documented on a consent form. The purpose, practicalities, potential benefits, side-effects and potential complications of treatment should be covered in both written and verbal formats understandable to the patient. An important aspect of consent is finding out and addressing what matters to the patient. If following peer review of outlining, there is any material change in perceived benefit or risk, this should be further discussed with the patient and documented as part of the ongoing process of informed consent.³⁹

3 Radiotherapy protocols

Departments should have agreed radiotherapy protocols for each tumour (sub)site. These should be agreed between departments working in partnerships and be ratified by the ODN or equivalent body in the devolved nations.⁴⁰ Protocols should include information on how to define TVs and OAR, dose-fractionation schedules, acceptable normal tissue constraints and planning techniques. Clinical trial protocols can provide useful examples of protocols and should be updated and adapted for local use.

Recommendation 2:

Target volume guidelines should be specified in protocols which should be standardised across a clinical network or ideally nationally or internationally.

In some clinical scenarios TVs can be described by normal tissue contours, for example in curative prostate or adjuvant whole breast treatment. The protocol should explain how to define volumes for all patients undergoing that therapy. If the protocol is followed, TVs should be concordant. These volumes are referred to as protocol-specified volumes.

Other situations require more individual judgement when defining volumes and there is more opportunity for variation or error. This includes where a gross tumour volume (GTV) is first defined and then expanded or when an individualised clinical target volume (CTV) is needed, taking into account features of the particular tumour or patient, for example, in most head and neck and curative lung cancer treatment. The protocol should give guiding principles for contouring this tumour type, but contours for each patient will necessarily vary. These volumes are referred to as individualised volumes. See Appendix 1 for examples of protocol-specified and individualised volumes.

No guideline or protocol can fully describe all possible scenarios. It is therefore appropriate to deviate from a protocol on a case-by-case basis if there are particular clinical or technical reasons to do so. Protocol deviations should be prospectively peer-reviewed and justification for the deviation should be documented in the patient record.

Volumes should be labelled systematically within each department, preferably with reference to the AAPM TG-263 standardised nomenclature. This recommends specification of relative dose levels (for example, PTV_High; PTV_Mid; PTV_Low) rather than specifying the physical dose.⁴¹

It is recommended that standard colour sets are used for contours within a department and ideally within radiotherapy partnerships and across organisations that share care such as radiotherapy ODNs. Although AAPM TG-263 elected not to make specific recommendations for colour use, the use of similar colours for isodose lines and structures, when the dose abuts the structure, is not recommended. A consistent approach minimises the risk of errors when interpreting contours. The views of staff members with visual issues such as colour-blindness need to be considered when selecting contour colours.

Recommendation 3:

A standard nomenclature should be used to label target volumes and organs at risk. Consistent colours should be used for volumes within each department.

4 Practical aspects of volume definition

Clinical oncologists should have dedicated and protected direct clinical care (DCC) time in their job plan for volume definition and peer review. No other tasks, including patient reviews, should be booked simultaneously.⁴² The timing of volume definition and peer review should take patient flow through the radiotherapy pathway into account to minimise treatment delays. Studies have shown that an accepted minimum time for such peer review meetings is one hour, where 8-10 cases at most are discussed.⁵⁸ Responsibility for ensuring compliance with this recommendation rests with the Departmental Clinical Director/Head of Service. Concerns and risks should be escalated via governance forums and the Trust Medical Director if necessary (Appendix 8).

Recommendation 4:

Professionals involved in contouring should have protected time in their job plans for target volume definition and for peer review of target volumes. No other tasks should be booked simultaneously. The amount of time required will vary depending on tumour sites and complexity. Job plans should be designed to enable peer review without delaying treatment pathways.

All relevant information must be available to the oncologist at the time of volume definition. This includes relevant diagnostic imaging, which should at least be viewable on a separate adjacent monitor to the planning computed tomography (CT) scan if not registered to it, clinic letters, operation notes, histopathology reports, clinical photographs, endoscopy reports and so on. It is the responsibility of the oncologist to ensure that these are reviewed and documented within the patient record.

Volume definition work should take place where the oncologist is not likely to be disturbed. The location will vary depending on the preferences and working pattern of the oncologist and facilities available within the department.

An appropriate working environment must be available for contouring with due consideration for ergonomics as set out by the RCR.⁴³ Visual displays should be of sufficient resolution and luminance for diagnostic cross-sectional imaging and should ideally include colour capability given the growing reference to positron emission tomography-computed tomography (PET-CT) and other dual modality functional imaging. Equipment should be subject to a regular QA programme.⁴⁴ Other functionality such as the outlining tools (for example, stylus, pen, mouse and so on), and technique (drawing points or a continuous contour) should be optimised. A general principle is that all available technology should be deployed to maximise the accuracy of contouring.

Recommendation 5:

Trusts should provide consultants with an appropriate working environment, including information technology (IT) infrastructure, to facilitate target volume definition.

Although in many cases oncologists contour in isolation, it is often helpful to have dialogue with the practitioners who generate the treatment plan to ensure a common approach to planning objectives, particularly in complex cases where there are critical normal structures close to the target. Where this does occur, it should be documented in the planning note. This approach enhances mutual understanding, education and teamwork as well as ensuring alignment of priorities during planning between the oncologist and planning staff.

5 Defining target volumes

GTV – gross target volume

The GTV is defined as the gross palpable or visible/demonstrable extent and location of malignant growth.⁴⁴ As such, GTV definition is the first link in the chain of tasks that results in the delivery of the desired dose of radiotherapy to the desired target.

Errors, and particularly omissions, in GTV definition have the potential to cause a geographic miss or suboptimal coverage of the tumour. The GTV is expanded to form the CTV and PTV so any errors in GTV definition are likely to be magnified in the CTV and PTV. Hence small errors in GTV definition can result in a PTV, and hence a dose distribution, which is suboptimal.

The oncologist should review all images in the planning scan dataset to look for other unexpected findings – new visible tumour, metastases, other gross pathology and so on. The planning CT is not usually acquired at a diagnostic image quality and the radiation exposure does not require a formal diagnostic report. Concern on the part of the oncologist

regarding a possible previously undetected abnormality on the radiotherapy planning scan should prompt full review of the planning scan by a diagnostic radiologist with appropriate follow-up action as required. However, clinical oncologists are not responsible for ensuring that all anatomical abnormalities on a radiotherapy planning scan are detected.⁴⁵

The radiotherapy planning CT should be viewed on a quality monitor using appropriate windowing.⁴² Diagnostic imaging using other modalities (magnetic resonance imaging [MRI] or PET-CT) should be registered where appropriate and the accuracy of the registration assessed. Also, the use of sagittal and coronal reconstructions can be particularly helpful when outlining irregular or vertically orientated structures such as the oesophagus. A dedicated MRI or PET-CT in the treatment position will give better results than deformed co-registration. Rigid image registration (RIR) aligns one image data set with another which can be the same or different modalities to more accurately define the GTV for treatment.^{46,47} However, RIR is potentially subject to inaccuracies caused by misregistration of deformable soft tissues for any number of reasons such as image artefacts, treatment effects, patient positioning and physiological effects (for example, peristalsis and respiration). There are various methods for applying deformable image registration (DIR) in what is a complex and evolving field in which specific techniques may be better suited to specific anatomical locations and where uncertainties about accuracy may remain.^{48,49}

Oncologists should seek advice from specialist diagnostic radiologists with specific understanding of the requirements of radiotherapy planning to help define GTV when needed. To facilitate contemporaneous radiologist access for the purpose of defining GTV, IT developments such as live online review should be supported. Radiologists should have training in the volumetric concepts of modern radiotherapy planning. Any radiologist involvement in volume definition should be recorded as part of documentation of peer review.

Autosegmentation algorithms have the potential to speed up contouring and to reduce variability and bias. There are a number of algorithms and methodologies which are most effective where tumour boundaries are well delineated by relatively large changes in pixel density compared with adjacent normal tissue; the lung is one site where autosegmentation may have greatest utility. Specific analysis of the performance of autosegmentation models requires both quantitative and qualitative validation where quantitative analysis is usually undertaken by a variety of 'similarity metrics' aimed at assessing the similarity to the 'ground truth' and where the qualitative analysis involves a head to toe comparison of the manual contours and autosegmentations for each patient. Machine learning (ML) based autocontouring is an area of active research interest and some commercial solutions are available.²⁴ As in studies of atlas based autocontouring, a proportion of contours generated by ML still require editing to be clinically acceptable, however, there is significant potential for machine learning to reduce the time required for the planning process.^{50,51} Nevertheless, there are limitations to autocontouring, particularly with structures that are poorly defined, mobile or have variable shapes.

If oncology centres are using autosegmentation tools, it is important that departments carry out adequate QA. The European Society for Radiotherapy and Oncology (ESTRO) has created guidelines on the implementation and QA of artificial intelligence-based applications in radiotherapy.⁵² It will be essential for clinicians using autosegmentation software to verify contours for each structure and each case prior to treatment.

Contours should not be cut and pasted from slice to slice of the planning CT as this risks errors being copied from one slice to another. If a contour is not defined on every slice, intervening contours can be automatically interpolated and the resulting contours individually checked for accuracy and edited appropriately.

CTV – clinical target volume

The CTV is the tissue volume that contains a demonstrable GTV and/or sub-clinical microscopic malignant disease that has to be eliminated in order to cure the cancer.⁵³

CTV encompasses possible sites of microscopic tumour spread. An absence of definitive data on pathological spread of cancer beyond the visible margins of disease and the lack of visibility of this target on the imaging used to inform planning, together imply that there will be variation in CTVs defined by different people. An element of this variation may be unavoidable, since this is a subjective judgement. However, variation in CTV definition from the same GTV can be minimised using consensus protocols.

The person performing contouring should apply their knowledge of relevant anatomy and pathophysiology to logically define possible routes of tumour spread. Atlases and trial protocols can be of use here.

While an isotropic expansion from GTV to CTV may initially be helpful, most tumours do not have the propensity for spread in every plane to the same degree. If a standard expansion is used, each slice contour should then be reviewed and edited to take account of natural barriers to tumour spread and possible routes of spread (for example, a normal vertebral body adjacent to a lung carcinoma should not be included in the CTV). While contours are usually defined on axial CT slices, planning systems allow reconstructions in other planes. These should be used where possible to help CTV definition, but final volumes should always be checked in the axial plane.

When a CTV is being defined for postoperative (adjuvant) radiotherapy, a review of the operation note and pathological findings as well as discussion with the surgeon and pathologist about most likely sites of recurrence is often very helpful. Registration of any preoperative imaging with the planning CT can be helpful to aid the definition of the CTV. Accuracy of the registration should be assessed and any changes in anatomy due to surgery should be taken into consideration if rigid registration is used. If deformable registration is used, again accuracy of registration should be assessed. It can be helpful for the surgeon to view the planning CT with the oncologist to help define possible sites at high risk for recurrence. Any dedicated remote peer review platform can facilitate such collaborative review to be undertaken remotely but in real time.

A number of CTVs for the same tumour may be defined so that different doses of radiotherapy can be delivered to each CTV to take account of different levels of risk.

Nodal atlases should be used when defining at-risk nodal volumes where there is no GTV visible. They need to be interpreted with caution in cases where there are nodes involved or if surgery has taken place as normal anatomy may have been altered.

ITV – internal target volume

The ITV consists of the CTV plus an internal margin. The internal margin is designed to consider the variation in the size and position of the CTV relative to the patient's reference frame (usually defined by the bony anatomy); that is, variations due to organ motion such as breathing or filling of the bladder or rectum.⁵⁴

Where motion can be estimated in individual patients, a composite GTV can be created and expanded to an ITV to account for movement in each plane – for example, using a respiration correlated or 4D CT for lung or oesophageal cancer.

PTV – planning target volume

Each department should audit systematic and random errors for each tumour site at an appropriate interval. These should be used to calculate departmental CTV–PTV margins for each site using equations such as the van Herk formula.⁵⁵ When there is a significant change in technique or equipment such as a new immobilisation device, margins should be re-audited.

It may occasionally be appropriate to modify the CTV–PTV margin for individual patients. This would depend on factors relevant to the individual case, for example an increased or decreased risk of set-up errors. The CTV–PTV margin will also depend on the method of image verification. For example, smaller margins could be acceptable if daily cone-beam CT with soft tissue matching is used.⁵⁶

PTVs should be expanded directly from the CTV or ITV and should then not be edited. Coverage of a PTV may be compromised to keep OAR within tolerance, but this compromise should be visible within the plan rather than being estimated by the oncologist changing the PTV. This may be achieved by creating a second PTV to describe the coverage necessary for the clinical case (for example, zPTV_optimised).

There are occasions where a structure needs to be created from the PTV for technical planning purposes, to produce more appropriate coverage – for example, a structure edited back from the skin surface in intensity-modulated radiotherapy (IMRT) for head and neck cancer planning.

OAR – organs at risk

OARs should be contoured and labelled according to the Global Harmonization Group consensus guidelines.⁵⁷ This publication may be subject to future updates which will be available at <https://rtqaharmonization.org/publications/>. OAR should be quality assured as rigorously as tumour TVs, for example with review by specialist radiologists as required.

A margin may be added to the OAR to create a planning organ at risk volume (PRV) when damage to a small volume of normal tissue may produce very severe side-effects (for example, in the spinal cord or optic nerves).

6 Which contours should be peer reviewed?

Prospective peer review should be performed in situations where a clinically important difference in judgement between oncologists might occur. These situations are usually where radiotherapy is being given with curative intent (radical or adjuvant). They include:

- All individualised volumes
- Any protocol-specified volume that does not conform to the department protocol
- Any protocol-specified volume defined within a new protocol where the volume is different to that used previously. Prospective review should continue until adequate audit shows that the new protocol is being followed appropriately
- Palliative treatments where volume definition is as complex as for curative or adjuvant cases. Examples include re-treatments and where high doses are used
- All peer reviewed volumes where major changes (for example, changes affecting the likelihood of cure or locoregional disease control) have been recommended. The revised volumes should be subject to further peer review to ensure compliance with the recommended changes.

For other situations a QA programme should be in place to assess quality of volume delineation. Departments should have an agreed programme for retrospective audit of volumes. For example, 10% of volumes could be randomly selected and audited at a peer review meeting. As random errors in a complex process are unpredictable, including some of these volumes in prospective peer review is recommended.

Retrospective audit of volumes should be performed for:

- Protocol-specified volumes that are defined according to protocol
- Routine palliative radiotherapy treatments
- Techniques where fields are defined according to a protocol rather than volumes.

Radiotherapy treatment is becoming more individualised as more information is available from imaging, tumour biology and genomics. It is therefore likely that increasing numbers of TVs will need prospective QA in the future.

Recommendation 6:

Prospective peer review of contours should occur in cases where considerable individual judgement is required, as well as in cases where major changes have been recommended at the time of initial peer review. In all other situations, a proportion of contours should be quality assured retrospectively. Departmental recommendations for either prospective or retrospective peer review should be protocolised and guided by published evidence.

7 Peer review meetings and documentation

The term 'peer review' as applied to radiotherapy contouring implies that all contours are reviewed by more than one consultant oncologist (or other peer professional with appropriate competencies) with the relevant site-specific expertise.

Timing of peer review

Peer review should take place before the first fraction of radiotherapy is delivered. For many tumour sites, review should occur after contouring but before a plan is created to reduce the risk of having to produce a second plan if changes are made. If the subsequent plan then meets the agreed PTV and OAR constraints it may not require further formal peer review. In some tumour types (for example, breast and lung) there may be benefit to reviewing the final plan rather than just the contours.⁵ Peer review can be performed collaboratively at a peer review meeting or remotely as is usually the case in clinical trials QA. Where possible, patients should be enrolled in clinical trials with prospective QA of TVs.

Organisation of peer review

Real-time QA meetings are strongly encouraged. They should ideally occur at a regular time each week and be scheduled in job plans to enable participation of the wider team. They should be timed so as not to add unnecessary delays into treatment pathways. QA meetings should include at least two clinical oncologists (or peer professional with appropriate competencies) with relevant site-specific expertise. In some departments this will necessitate the meeting being linked by videoconferencing. The treating or 'principal' clinician should be present where possible. The IT infrastructure should allow all participants to view the contours. It is desirable for such a meeting to also be attended by oncologists in training, radiologists, physicists and dosimetrists/radiographers. The time needed for a peer review meeting will vary according to the number and complexity of cases to be discussed, the participants and their experience with the process. Taking an average duration of case discussion as 10 minutes for a case requiring a major change, and 6 minutes for a case requiring no change or minor change, radiotherapy departments should realistically expect no more than 10 cases per hour to be scheduled.⁵⁸

Setting up and resourcing such meetings will be challenging in many departments. Consultant time should be acknowledged in job plans and be adequately funded. Peer review can also be completed on an on-demand basis by reviewing cases with colleagues throughout the week once contours are completed. This approach can be more efficient but should be complemented by intermittent meetings to facilitate education and consistency across the department. On demand peer review should be documented in the same way as regular peer review. Scheduling of the meetings and of other radiotherapy tasks before and after peer review meetings should be reviewed so that patient flow and cancer waiting times targets are not adversely affected. Arrangements for leave cover need to be considered. Innovative IT solutions to enable networked peer review meetings will need to be devised and resourced in many departments. While peer review should be structured, some flexibility is also important. For example, it may be helpful to review a GTV with a colleague (oncologist or radiologist) before going on to define the CTV. See Appendices 3 and 4 for examples of peer review in practice.

Recommendation 7:

Trusts and Cancer Alliances should facilitate peer review between departments by investing in appropriate IT infrastructure.

Contours can also be peer reviewed remotely as is the case in clinical trials QA where an established methodology exists. Contours and plans are sent electronically for review and feedback by a peer or team of experts. Excellent communication between the oncologist and reviewers is key to ensure all relevant information has been considered when agreeing a final plan. This approach may have particular value in rare tumour types where expertise is necessarily centralised or in smaller departments with sole practitioners, where job plans do not lend themselves to real time (in person or virtual) peer review.

Recommendation 8:

Each department should have an agreed process for peer review of target volumes. The frequency and nature of peer review should be specified for each tumour site depending on the complexity of the volumes and should be reviewed periodically to ensure sufficient time for discussion of cases. Departmental process documents for peer review should also specify the necessary and desired attendees.

Content of peer review

The clinical particulars of the case should be discussed with access to all relevant clinical data, for example diagnostic imaging, pathology reports and operation notes. The overall treatment intent, radiotherapy dose and fractionation, and concomitant therapy should be noted. The oncologist who has defined the volume (principal clinician) should ideally be present to explain how the TVs have been defined, though these details should also be recorded on the planning note. Areas of uncertainty should be highlighted and discussed. Other experts should also look for evidence of deviations from protocol and for random errors (for example, GTV that has been inadvertently missed).

If a consensus cannot be reached, the final decision to proceed with treatment rests with the principal clinician in discussion with the patient. If a reviewer is very concerned and feels that their view has not been adequately assessed and reflected on by the principal clinician and there may be clinical risk, then other governance structures can be used. For example, advice may be sought from a clinical director or governance lead who may ask for a review from a pre-specified team in a neighbouring centre.

Once TVs have been agreed, treatment plans which are created to agreed PTV and normal tissue constraints are checked by more than one dosimetrist/physicist. They are usually signed off by a clinical oncologist so there is a checking process in place without the need for each plan to be peer reviewed as well. However, peer review of treatment plans is conducted in many centres internationally and as this can facilitate inter-disciplinary learning and education it is considered good practice.⁵⁹ Any plans not meeting agreed constraints should be routinely reviewed by the wider multidisciplinary team and recorded.

Contouring and peer review

The principal clinician should add a planning note to the patient's case record for all radiotherapy treatments, akin to an operation note (an example, planning note and peer review record is included at Appendix 5). This should document how volumes were defined, with reference to protocols as necessary. For a protocol-specified volume, reference to a protocol may be all that is needed. More detailed notes may be needed for individualised volumes, for cases where a protocol has not been followed or where there are deviations from a standard protocol. This should facilitate future audit of treatment volumes retrospectively, particularly when patterns of recurrence are being studied.

Recommendation 9:

A planning note should be written for each radiotherapy course explaining how and why target volumes were defined, with reference to protocols as necessary.

When peer review is performed it should be documented. Documentation also acts as a checklist to ensure all relevant metrics have been reviewed. The document should include a record of the participants and of any changes made to TVs, radiotherapy doses or concomitant treatments. The terms 'major change' and 'minor change' are suggested to help provide some quantification. While these terms have not been consistently defined in the literature and between tumour sites, it is recommended that radiotherapy centres adopt the definitions of major and minor changes.⁶⁰ Here, major changes include any changes which would affect the likelihood of cure or locoregional disease control, while minor changes are those which would not affect this. (See Appendix 6 for a summary table of definitions of major and minor changes, and Appendix 7 for a list of examples of major and minor changes). Cases recommended for major changes should return to peer review for assessment and documentation of amendments made. If remote QA is performed (for example, within a clinical trial), the principal clinician should write a planning note and should include evidence of remote QA in the form of a standardised report. Documentation should be in a format that can be made available retrospectively for purposes of audit and appraisal. Embedding documents within electronic radiotherapy systems makes this easily auditable.

Collecting quantitative data such as conformity index is unlikely to help inform individual cases but may be useful in a research context. A useful appraisal of different quantitative metrics can be found in the literature.²⁷

Audit of peer review

There is a risk that the peer review meetings may have biases – for example, if all clinicians are making the same incorrect assumptions about a contour and coming to an incorrect conclusion by consensus bias. External QA of peer review meetings is therefore recommended, for example by clinicians attending other peer review meetings. Peer review meetings in a department should be audited annually and discussed at an appropriate forum such as the local radiotherapy board.

Recommendation 10:

Radiotherapy departments should use a standardised peer review outcome record template which will facilitate audit of their processes in relation to QA, peer review of target volumes, review of amendments in target volumes after peer review and review of radiotherapy treatment plans. Such audits should form part of each radiotherapy departments' annual audit programme.

Outcomes of radiotherapy treatment, including both tumour control and late effects, should also be audited locally or nationally, analysed and reflected upon. When a treatment is not successful, a retrospective review of the treatment volumes with the imaging at recurrence is recommended, with co-registration if possible, to feedback any learning points and contribute to audits of patterns of failure. Loco-regional recurrences can be classified as in-field, marginal or out-of-field and such information may inform better volume definition in the future.

Recommendation 11:

Departments should audit radiotherapy outcomes in terms of loco-regional control and toxicity and should therefore be able to use such data to better inform target volume definition in the future.

**8
Education and
continuing
professional
development (CPD)**

Clinical oncologists and other professionals involved in contouring should be able to evidence competency and continuing professional development (CPD) with respect to volume definition for the relevant tumour sites as part of appraisal and revalidation. While currently there is no reference to contouring and plan peer review in the clinical oncology curriculum, that is expected to change in future as the benefits for QA of radiotherapy service provision become more embedded in every department. This could be demonstrated in several ways:

- Evidence of attendance at relevant peer review meetings
 - Evidence that their individualised volumes have been peer reviewed at such meetings, and documented reflections where major changes have been recommended
 - Evidence that their protocol-specified volumes are defined according to protocol and that a suitable proportion of them have internal or external peer review
 - External QA of volumes in a radiotherapy clinical trial where test cases undergo central QA or where patient volumes within the trial are prospectively audited
 - Participating in QA workshops such as the stereotactic ablative radiotherapy (SABR) contouring programme organised by the SABR Consortium or outlining workshops arranged by the RCR using AQUILAB.
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Recommendation 12:

Clinical oncologists should be able to evidence good contouring and engagement in QA of target volumes as part of annual appraisal.

Expertise in radiotherapy target definition, as in all radiotherapy tasks, is likely to increase with experience and number of patients treated. Oncologists should treat a number of patients with each cancer type consistent with retention of competency and should comply with any nationally agreed standards in this regard.

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Appendix 1

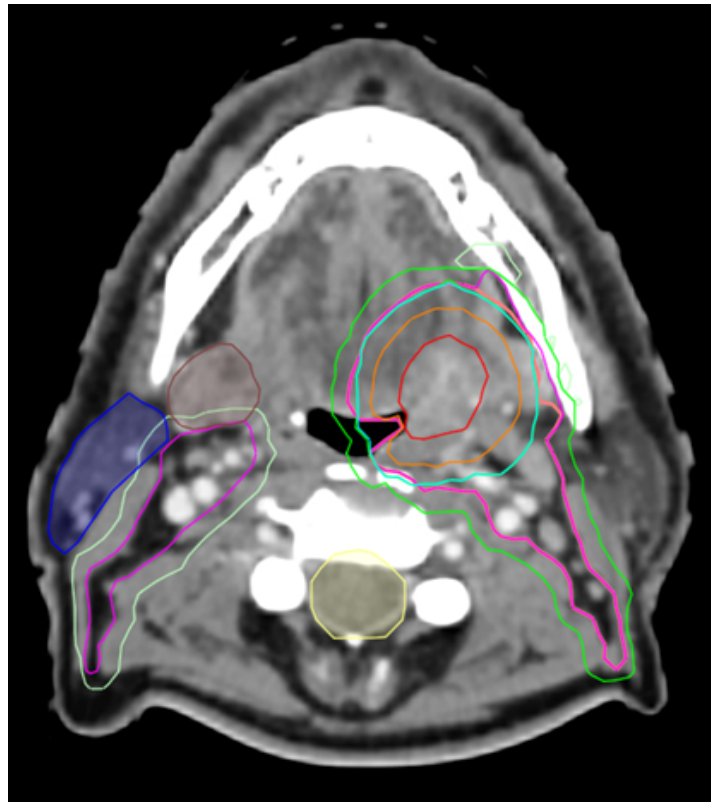
Examples of protocol-specified and individualised volumes

Site	Protocol-specified	Individualised
Bladder	Curative radiotherapy to whole bladder	All curative treatments except for radiotherapy to the whole bladder
Breast	Adjuvant radiotherapy to whole breast +/- nodes	Radiologically identified residual nodes such as supraclavicular or internal mammary nodes, being treated with curative intent
Colorectal and anal	–	All curative treatments
Gynaecological	–	All curative treatments
Head and neck	-	All curative treatments
Lung	–	All curative treatments including SBRT
Prostate	Curative radiotherapy to whole prostate	Prostate + nodes Adjuvant radiotherapy to prostate bed
Sarcoma	–	All curative treatments
Upper gastrointestinal	–	All curative treatments

Appendix 2

Sample contouring labels

Suggested contour labels and colours for a head and neck treatment. 65Gy in 30 fractions to high dose target volume, 60Gy to intermediate dose and 54Gy to low dose.



Target volume	Colour
GTV	Red
CTV_65	Orange
PTV_65	Cyan
CTV_60	Light pink
PTV_60	Green
CTV_54	Magenta
PTV_54	Light green
Parotid_R	Dark blue
GlnD_Submand_R	Brown
SpinalCord_PRV	Yellow

Appendix 3

Examples of peer review meetings in UK departments

In addition to the examples listed here there are several papers that detail how peer review is carried out in individual departments in the UK and abroad. These include references by Ballo, Brammer, Amarasena, Lefresne, Lymberiou, Mackenzie and Rooney.^{4-6,8-10,12}

Head and neck peer review meetings with three head and neck oncologists (Norwich)

Job plans of the three oncologists have been aligned so that they all have a contouring programmed activity (PA) on a Monday morning with no other activities scheduled at that time. At a 30-minute head and neck team meeting on the preceding Wednesday oncologists, trainees, dosimetrists and physicists briefly discuss each case to agree on dose, fractionation and selection of nodal levels as well as which oncologist will contour which patients. Volumes which may need radiologist support can be identified so that discussion with a specialist radiologist can take place without delaying contouring.

Workflow has been streamlined so that head and neck patients are scanned on a Thursday or Friday so as to be ready for contouring on Monday.

On Monday mornings the oncologist contours target volumes and organs at risk, liaising with their colleagues during the process if needed. Peer review is therefore dynamic and may occur several times during the course of contouring for complex volumes or just once when the contours are complete for simpler cases. This means that changes are made early on in the planning process making corrections more efficient – so if the GTV is changed by peer review, such changes can be reflected in the CTVs when they are defined subsequently.

The isotropic expansion from CTV to PTV is completed only when at least two oncologists have agreed on CTV definition. Contours are then electronically signed as complete so that planning can begin.

A planning note is completed electronically and acknowledges changes made by peer review and the fact that all oncologists have contributed to the final contour sign off. Peer review usually takes 10 to 20 minutes per case but because review happens in real time during contouring it may reduce time spent considering uncertainty and correcting contours. Oncologists are much more confident that target volumes are optimal when they have been peer reviewed.

Lung cancer meetings in a centre with six lung oncologists (Belfast)

CT voluming and assessment of plans is done at various times throughout the week, as dictated by the differing job plans of clinicians. Trainees are encouraged to select patients from any consultant and contour them before discussing with the relevant consultant. When a doctor is on annual leave other consultants will cross-cover activity. Relevant clinical data is written on the radiotherapy planning information to enable voluming (stage, World Health Organization [WHO] performance status, results of respiratory function tests, Medical Research Council [MRC] dyspnoea score, proposed fractionation and treatment paradigm).

On a Wednesday morning clinicians meet for up to 90 minutes to discuss all cases that have been volumed or are available for dose–volume histogram (DVH) and plan evaluation. At least two oncologists are required to be present to make the meeting quorate. The meeting is also attended by a specialist radiographer and oncology trainees. There is access to the radiotherapy planning system and the radiology and online oncology notes systems. A

Microsoft Access database is used to record patient details, meeting attendance and peer review outcomes (see picture below).

Screenshot to show data fields which are completed at peer review meeting

The screenshot displays the 'Peer Review Lung Database' form. The form is organized into several columns of input fields and checkboxes. The fields include:

- Demographics:** ID (with a 'New' button), Initial, BPR, cons, Histology, Treatment Paradigm, PET/CT staging, FEV1, TF, Respiratory Compensation, Peer Review Treatment Indication, Peer Review Treatment Indication Changed, Peer Review Volume Date, and Changed Peer Review Volume.
- Clinical Data:** Age, PS, T, N, PLNS, M, MRC Dys, %FEV1, %FVC, brain staging, iv contra, Gender, and GTV volume.
- Review and Action Items:** PR Volume change - date accepted, Peer Review DVH Date, MLD, Lung V20/V18, oesophageal V50, Spinal Cord PRV max, mean heart, Changed Peer Review DVH?, PR DVH accepted if previously declined, Peer Review Dose Date, Dose prescription, Changed Peer Review Dose?, PR Dose accepted if previously declined, and Comments.
- Checkboxes:** VMAT or IMRT, Type B algorithm, 99%+ PTV 95% dose, 99%+ CTV 95% dose, 95%+ PTV 95% D, 99%+ PTV 90% dose, Salvage, 2 primaries, Oligomet, Lung nodules (T3/4), and Replan needed.

The treatment paradigm is discussed and agreed. Volumes are reviewed by the meeting in the context of the radiology and clinical details (pathology and endobronchial ultrasound [EBUS] reports). Any required changes are discussed and made at the meeting if possible. If a modification is recommended this is recorded in the database and a date made for review of the changes (usually the following week). The degree of change is graded as major or minor. Plans for evaluation are reviewed in the context of the clinical data (fitness of the patient, co-existent comorbidities and proposed concomitant medications). Any change in dose or advice to proceed to IMRT/volumetric modulated arc therapy (VMAT) is recorded. A treatment is allowed to progress with retrospective review at the meeting if there is clinical priority, although the department is aware that the meeting may necessitate changes that are usually more difficult to implement once treatment has begun. Additional cases are often discussed so that advice from colleagues can help management decisions such as whether a patient has a radical treatment option.

The meeting allows team building and rapid cascading of new information from clinical trials and discussion of possible service developments. All clinical oncologists involved feel more confident when their patient's treatment has been discussed at peer review. The database allows a record of peer review meetings attended and consultant cases put through the meeting which can be used for appraisal.

Online head and neck cancer peer review meetings using Microsoft Teams (Taunton, Exeter and Torbay)

Taunton is a radiotherapy centre which used to have just one head and neck oncologist. Exeter, Taunton and Torbay already video link weekly for the head and neck cancer multidisciplinary team meetings (MDTMs). In 2014, the Exeter and Taunton clinical oncology centres worked together to identify IT solutions to facilitate cross-site peer review of radiotherapy contours and treatment plans for their patients. Previously Skype for Business was used, but latterly Microsoft (MS) Teams is the platform allowing remote but real-time peer review of cases across all three centres, including the facility for screen sharing and contemporaneous amendment of contours.

Currently, two oncologists from Taunton, two from Exeter and two from Torbay, have protected time in their job plans for one hour of contouring peer review on a Monday after the head and neck MDTM. Clinical staff at all three sites – trainees, radiographers and physicists – are invited to join the weekly meeting via a MS Teams invitation with a link to the session. The outcome of each case peer review is recorded in a standardised template at the relevant trust (for example, Mosaik at Taunton, Aria at Exeter).

On demand head and neck peer review in a centre with four head and neck oncologists (Birmingham)

An on-demand peer-review approach has been piloted so as not to introduce any delay into the radiotherapy pathway by waiting for a weekly meeting. Cases are submitted by contouring clinicians for peer review on a voluntary basis. On completion of contouring, an 'await peer review' comment is entered on the contouring software by the contouring clinician. The clinical scenario, rationale for dose and volume selection, treatment start date or 'review-by' date and any specific clinical concerns are detailed. The focus of peer review is on TVs; OARs in each case are contoured by an experienced head and neck specialist radiographer and reviewed by the contouring clinician.

Clinical details and relevant pre-treatment imaging are reviewed by the peer prior to contour review. All clinicians follow institutional protocols with delineation guidance reflecting contemporary UK practice. The guidelines are closely aligned to relevant prospective national studies: oropharynx (CompARE trial), larynx and hypopharynx (NIMRAD trial), parotid (CO-STAR trial). The peer review can be done either independently, or alongside the contouring clinician. If the case is rare or complex, or a corroborative opinion is requested by the contouring clinician, peer review can be performed by more than one peer either together or sequentially. Once peer review of contours is complete and any amendments finalised by the contouring clinician, a 'peer review completed' saved entry confirms the case is ready for planning.

A pilot study has been undertaken to evaluate this approach in 62 cases. The mean review time was 17 minutes per case. 11% of cases required significant changes and these cases were usually complex – for example, sinonasal cancer or post induction chemotherapy cases. The mean (and median) time saved in completing peer review between an on-demand approach versus a weekly approach was 27.9 (18.8) working hours respectively ($p < 0.001$). The next steps are to improve the pathway through integration with MOSAIQ and to complement on-demand peer review with intermittent review meetings.

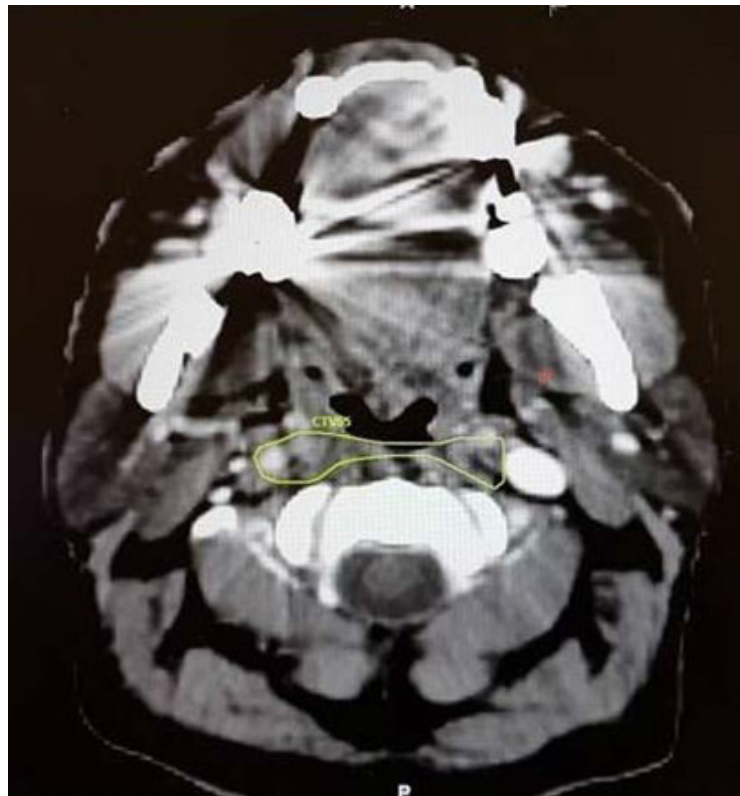
Appendix 4 Individual case examples of peer review

An example of peer review correcting a judgement error

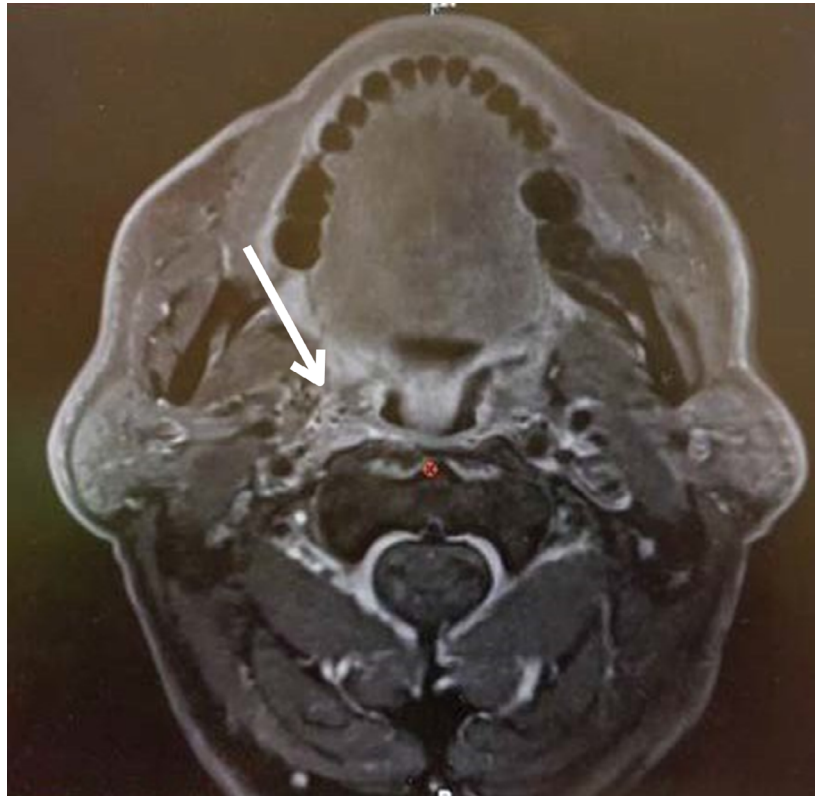
A patient with T4N1 Epstein-Barr virus associated nasopharyngeal cancer was being planned for curative radiotherapy following neo-adjuvant chemotherapy. At diagnosis a right retropharyngeal (RP) node was thought to be involved. Pre-chemotherapy and post-chemotherapy MRI images were fused with the planning CT scan to aid contouring. The RP node was not enlarged on the post-chemotherapy MRI but should have been included as GTV according to local protocol. This was not recognised at contouring so the involved node was excluded from the GTV and CTV₆₅. Peer review was undertaken on demand by a second specialist consultant. At review this unintentional error was detected and corrected with both clinicians present before a plan was created. The involved RP node was contoured as GTV which resulted in an additional 28mm expansion of the CTV₆₅ to cover the RP nodes.

Without peer review the involved node would not have received the intended radiation dose making a recurrence at that site more likely. There are no good surgical salvage options for RP nodes so any recurrence would likely be incurable.

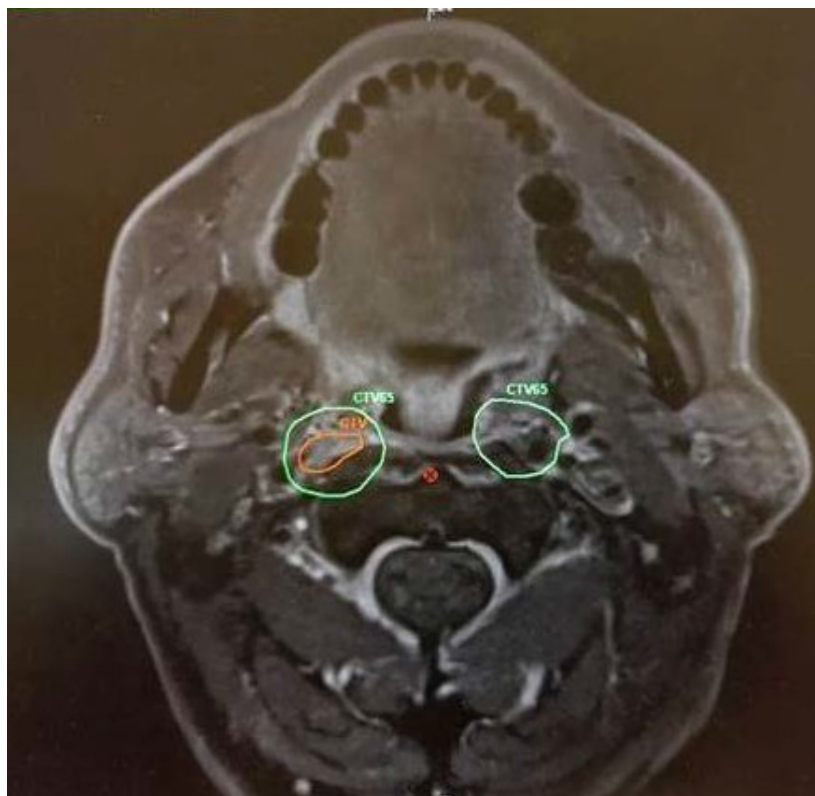
Planning CT prior to review. Most inferior contour for CTV₆₅ is shown (yellow)



Diagnostic MRI showing involved right retropharyngeal node



Peer reviewed GTV(orange) and CTV_65 (green) contoured on MRI fused with planning CT



An example where peer review might have prevented recurrent cancer

A patient was assessed for curative radiotherapy for a locally advanced lung cancer. Her PET-CT described multiple N2 lymph nodes and biopsy of a subcarinal lymph node produced cells consistent with squamous carcinoma. Her radiation oncologist outlined a left upper lobe primary and subcarinal and hilar lymphadenopathy. The paratracheal lymph nodes were not included as these were not mentioned by name in the pathology or PET-CT report, although on retrospective review of the PET-CT images these nodes were moderately fludeoxyglucose (FDG) avid. They also looked abnormal on endobronchial ultrasound.

The patient subsequently relapsed in the paratracheal lymph nodes and received palliative systemic treatment. A review determined that the paratracheal lymph nodes had been excluded from the GTV and received minimal dose. The oncologist noted that she had started attending peer review meetings where cases had a 'second look' and that her colleague had described target nodal revisions of a similar type being advised by the meeting. The patient's family lodged a complaint and compensation was sought.

Appendix 5

Suggested peer review outcome record template*

	Detail	Peer Review Outcome	Description
Patient information	Name DOB ID		
Diagnosis & staging (TNM)			
Treatment intent		MAJOR MINOR NO CHANGE	
Treatment technique		MAJOR MINOR NO CHANGE	
Dose/fractionation		MAJOR MINOR NO CHANGE	
Concurrent chemotherapy?		MAJOR MINOR NO CHANGE	
GTV		MAJOR MINOR NO CHANGE	
CTVs		MAJOR MINOR NO CHANGE	
PTVs		MAJOR MINOR NO CHANGE	

	Detail	Peer Review Outcome	Description
OARs		MAJOR MINOR NO CHANGE	
Other comments		MAJOR MINOR NO CHANGE	
Review of plan parameters		MAJOR MINOR NO CHANGE	
Has the recommended change been carried out in real time and subsequently agreed?		YES NO	
Does case need to be brought back for further review of amendments?		YES NO	
Which guideline/protocol was used?			
Time taken for discussion			
Peer review meeting format (e.g. face-to-face; via video-link etc.)			
Peer review discussion documented by			
Date			

* Lewis PJ, Court LE, Lievens Y, Aggarwal A. Structure and Processes of Existing Practice in Radiotherapy Peer Review: A Systematic Review of the Literature. *Clin Oncol (R Coll Radiol)* 2021; 33(4):248-260

Appendix 6

Definitions of major and minor changes recommended at peer review

	Change which would affect the likelihood of cure or loco-regional disease control
Major Change	Change requiring editing of a contour (GTV or CTV) by more than 1 cm in any direction, or to prevent geographic miss of target
	Change in dose or number of fractions
	Change in treatment modality
	Change in treatment intent
Minor Change	Change which would not affect the likelihood of cure or loco-regional disease control
	Change requiring editing of a contour by less than 1 cm

Appendix 7

Examples of major and minor changes found at peer review

Tumour site	Examples of major changes	Examples of minor changes
All	<ul style="list-style-type: none"> Change in treatment modality – for example, addition of concomitant chemotherapy Change in radiotherapy dose or fractionation Any change needed to prevent a geographic miss of GTV Change in treatment intent 	<ul style="list-style-type: none"> Editing a contour by a small amount – for example <10 mm
Head and neck	<ul style="list-style-type: none"> Deciding to include a lymph node within GTVn where peer review consensus is that the lymph node is involved Including or excluding a whole nodal level in a CTV 	<ul style="list-style-type: none"> Excluding an uninvolved muscle from CTV Minor editing of CTVs to correspond to the consensus atlas contours for N0 neck
Lung	<ul style="list-style-type: none"> Change from concurrent to sequential chemotherapy Change from conventional fractionation to stereotactic body radiotherapy (SBRT) Alteration of GTV to reduce geographic miss (inclusion of lymph node felt to be involved, addition of spiculation felt to be pathological) Modification of OAR that affects plan acceptability (for example, DVH becomes out of tolerance) 	<ul style="list-style-type: none"> Alteration of OAR that does not affect plan acceptability Minor modification of GTV that does not affect target coverage (area may have been included on other GTV contours in other phases of respiration)

Tumour site	Examples of major changes	Examples of minor changes
Upper gastrointestinal	<ul style="list-style-type: none">▪ Incorrect expansion of GTV to CTV longitudinally▪ Change in longitudinal GTV by more than 5 mm▪ PTV margin deviation from protocol	<ul style="list-style-type: none">▪ Incorrect delineation of areas of elective nodal irradiation for example, some areas not included▪ Incorrect PTV margin but ≤ 3 mm deviation from protocol

Appendix 8

Example risk assessment for 'single point of failure' clinical oncologists

This risk assessment was used to demonstrate non-sustainability of the lone practitioner service and the risk to patients of lack of ability to undertake contouring peer review (see Risk H). It supported the introduction of dedicated radiotherapy contouring peer review in job plans and from there, the business case for additional clinical oncologists.

HOSPITAL		Ref no.	
DIVISION		WARD/DEPT	
HAZARD (something with the potential to cause harm) Include patient's name & hospital number if applicable		Single Point of Failure; Lone consultant oncologist for specified sub-specialty of Oncology service:- Head and Neck (CCO)	
RISK – who might be harmed and how (tick if applicable)		<input type="checkbox"/> reported incident	<input type="checkbox"/> perceived risk
TYPE OF RISK – identify each separate risk associated with the above hazard			Persons at risk []
A	Impaired ability of single oncologist to promptly see new patients and patients with potential relapse, resulting in fragmented care and the need for additional clinics	S[] V[] P[] O[]	
B	Increase in cancer waiting times and subsequent increase in cancer breaches	S[] V[] P[] O[]	
C	Adverse effect of increase in cancer waiting times and subsequent increase in cancer breaches on Trust's reputation	S[] V[] P[] O[]	
D	Interruption to pathway at times of consultant leave	S[] V[] P[] O[]	
E	Increased workload pressure on other team members causing stress and affecting staff morale	S[] V[] P[] O[]	
F	Increased workload pressure not conducive to quality service and patient safety	S[] V[] P[] O[]	
G	External concerns raised (peer review) resulting in immediate concerns or negative public coverage of service	S[] V[] P[] O[]	
H	Inability of single oncologist to provide quality assurance of radiotherapy contouring resulting in risk of tumour recurrence/ locoregional failure	S[] V[] P[] O[]	
S = Staff V = Visitor P = Patient O = Other			

EXISTING CONTROL MEASURES – What control measures are in place for each risk in addition to current Trust Policies and Procedures?	
Insert A B C D or E to refer back to the above risks	
ABCDEF	Extra clinics are being done when demand increases or around time of planned absence to avoid delays in starting treatment
ABCDEF	Currently during planned emergencies, existing Oncologist covers any patients that require urgent treatment at times of planned absence
ABCDEF	Identifying patients at MDTs, to anticipate demand and where possible 'blocking' clinic appointments for patients that will be referred to compensate for leave
ABCDEF	Arrangement for clinical supervision programme to be put in place to provide appropriate support to medical staff
ABCDEF	Directorate wide review of administrative meetings to ensure that clinician time is prioritised to patient facing care as appropriate.

EVALUATING RISK (see guidance for definition of rating system)					
Risk	Consequence (1–5)	X	Likelihood (1–5)	=	Risk Score (1–25)
A	2d	X	4	=	8
B	3d	X	3	=	9
C	2l	X	3	=	6
D	3d	X	3	=	9
E	2c	X	2	=	4
F	2a	X	2	=	4
H	3d	x	4	=	12

ACTION PLAN – Are existing precautions adequate or is further action required to eliminate/reduce the risk?

NOTE: If this is a manual handling, patient fall, COSHH, DSE or pregnancy related assessment, please ensure that a specific risk assessment is also in place where necessary.

Insert A B C D or E to refer back to the above risks. I = immediate M = medium L = Long term

Risk	Further Action/Training Required To Control Risk (detail who will be responsible for action)	I, M or L
ALL	Review of oncology pathways to support improved resilience. This will help with planning and anticipating clinical workload and improve the patient pathway	I
ALL	Explore the development of the consultant radiographer post to incorporate support of appropriate oncology pathway and treatment within her remit.	M
ALL	Support continued funding of additional clinics when required to accommodate times of increased demand, avoid breaches and facilitate uninterrupted patient treatment pathway.	I
D,E,F	Development of link between Physics departments at Taunton & Exeter or Bristol, to allow: Consultant Peer Review of radiotherapy contours; the ability for consultants at either site to sign of the other's radiotherapy plans; the ability for consultants at either site to undertake contouring for patients coming through radiotherapy planning in a timely fashion	M
ABCDEFG	Additional medical support for lone consultant – either through specialty grade support or through joint appointments across Trusts (Exeter, Weston and/or Yeovil)	M/L

ASSESSMENT SIGN OFF All Risk Assessments should be added to the relevant tier of the risk register

Assessor's Name		Manager's Signature	
Assessor's Signature		Date	
Date of Assessment		Local monitoring to be performed by:	
Review: (please circle)	continuous daily weekly monthly yearly after significant change		

Appendix 9
Other useful
resources

Published consensus contouring guidelines

<https://econtour.org/references>

European Society for Radiotherapy and Oncology (ESTRO) Contouring workshops

www.estro.org/Congresses/ESTRO-2022/Contouring-workshops-ESTRO-2022

ProKnow – online analytical tools for radiation oncology to reduce variability

<https://proknowsystems.com/>

Quantec – Quantitative analyses of normal tissue effects in the clinic

www.redjournal.org/action/showPdf?pii=S0360-3016%2809%2903300-8



The Royal College of Radiologists. *Radiotherapy target volume definition and peer review, second edition: RCR guidance*. London: The Royal College of Radiologists, 2022.

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