IMRT Protocol

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IMRT Protocol

RADIATION ONCOLOGY

Please refer to anatomic atlas for pictorial guidance on definitions of various nodal regions. These atlases are available in electronic and written format in the Doctor's Pinnacle area.

1.1. Dose Specifications

Prescription dose shall be according to the following specifications:

- All targets will be treated simultaneously each day (i.e., integrated boosts where needed). The standard protocol for treatment breaks/"down" days apply.
- The prescription dose is the 100% isodose that travels through the isocentre (or nominated calculation point) and 95% of this dose will encompass the entire primary and nodal PTV assigned to that dose. Wherever differential doses are applied, 95% of those doses will encompass the relevant differential PTV. The maximum dose covering more than $2cm^2$ will be no more than 107% according to ICRU52/60.

1.2. Technical Factors

- Megavoltage equipment capable of delivering static intensity modulation with a multileaf collimator, signed off by radiation physics staff.
- Only 6 MV energy photon beams should be used

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1.3. Localization, Simulation, and Immobilization

Visualising the gross tumour volume and at risk areas for target construction is paramount. Oncologists may use markers and contrast in the following manner:

- **IV contrast** will aid the delineation of vascular structures around which lie the lymph nodes.
- **Image fusion** is permitted and is of particular benefit when the tumour remains *in situ*. Fusion of PET and/or MRI scan should be notified to planning staff. Fusion should be undertaken with reference to the 'immobile' bones of the region.
    - **MRI scans** should be undertaken in the treatment position
        - request the MRI with the phrase "planning scan for fusion")
        - request slice width of 2mm (identical to planning CT)
        - request scan extent
        - request flat top

Patients will be immobilized with an **immobilization device** and will be treated in the same immobilization device.

- Positioning details should be determined before immobilisation is undertaken.
- Positioning of bolus should be determined before immobilisation and placed under the immobilisation device, typically wherever gross disease comes to within 5mm of the skin surface.

The treatment planning CT scan should be acquired with the patient in the same position and immobilization device as for treatment, have a **slice width of 2mm** and extend from at least **4 cm above to 4 cm below** the clinical interest area.

- Multiple treatment planning CT scans may be required to determine the Internal Margin.

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1.4. Treatment Planning/Target Volumes

Gross Tumor Volume (GTV)

- *definition*
  all visible gross disease, that is, all abnormal anatomy from CT/MRI and clinical information
- *delineation*
  sole responsibility rests with the radiation oncologist
- *extent*
  includes no normal tissue margin as per ICRU definition
- *notes*
  For post-operative patients with no visible gross disease, there should not be a GTV. Fat with abnormal signal should be included in the CTV unless tumour nodules can be seen.
  GTV definition will vary markedly between modalities and a hierarchy of importance should be considered with PET first followed by MRI then by CT in soft tissues, but when determined from several modalities, severe caution is advised if reducing GTV margins.

Clinical Target Volume (CTV)

- *definition*
  areas which are at risk of containing disease, which contains the visible GTV (risk = 1.0) as well as sites of potential involvement (no gross disease to see) based on natural history of disease
- *delineation*
  is the sole responsibility of the radiation oncologist and includes:
- *extent*
  there are two considerations for delineating a CTV. The area around the GTV where the CTV will breach anatomical boundaries to cover local extent, and secondly areas without visible cancer where the risk will be confined within visible anatomical boundaries.

  - a **margin for local sub-clinical extension**
    a small amount of data indicates that a 3mm margin into normal tissue is an adequate pathological margin
  - delineation of apparently normal tissue areas (e.g., nodes), which is not a simple expansion, but rather a **deliberately shaped volume** that respects anatomical boundaries
    - The nodal CTV includes lymph nodes that drain the involved site and adjacent perinodal soft tissue centred on the blood vessel which can be seen.
      - The relevant draining **nodal stations** should be identified by name. The nodal CTV is initially identified by the vessels and then is manually enlarged to include the perivascular tissues which contain the nodal tissues. The nodal CTV in the N0 scenario follows the following rules:
        - found around blood vessels
        - found within the fat through which the vessels course
        - not found within the surrounding tissues such as muscles, bones or bowel

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- In the post-operative setting, the presence of **clips** should alert the radiation oncologist to a site of interest.

Planning Target Volume (PTV)

- *definition*
  PTV will provide a margin around the CTV that compensates for the Setup Margin (daily variability of treatment setup) and Internal Margin (organ movement)
- *delineation*
  no staff member is responsible for defining the PTV as it uses margins determined independent of any clinical thought process. The exact margin is provided to planning by measurements on the machine for the standard technique and so is not guessed or estimated. Careful consideration should be made when defining the superior and inferior margins in three dimensions. **PTV cannot be altered by any staff member unless treatment setup changes**. PTVs are to be constructed by **software expansion using a symmetrical margin** (anteriorly, posteriorly, laterally, superior and inferior directions) around CTVs
- *extent*
  For H&N treatment, a 3 mm symmetrical margin is used because daily imaging is undertaken to correct for anything more than a 3mm error.

Naming Conventions for Volumes (see Diagram)

GTV

- GTV is a clinical volume and so should be named clinically, thus:
- The voluming that defines the primary mass might be called the **GTVp**.
- The voluming that defines all of the nodal masses might be called **GTVn**.

CTV

- CTV is a clinical risk volume and so should be named clinically. It is determined on two levels:
  - CTV is provided as an adequate margin around any GTV for local extension
    - GTVn → **CTVn**
    - GTVp → **CTVp**
  - other CTVs are provided on the basis of sub-clinical disease risk and named accordingly
    - **CTVn0**
      CTV defining the volume without visible disease, i.e., clinically node negative, and so excludes CTVp and CTVn

PTV

- The PTV is generated from the structures determined above (i.e., CTVp, CTVn, CTVn0) with the expansion margin corresponding to the measurement of SM & IM undertaken routinely. As this is a planning volume, it should be named so as to remove any clinical ambiguity. Thus the radiation oncologist will expand their CTVs to produce a **volume-dose structure** such as **PTV70**, where the new volume is intended to receive 70Gy at calculation point with homogeneity coverage of 95% to107%.
  - PTV45, PTV50, PTV60, or PTV70, etc.

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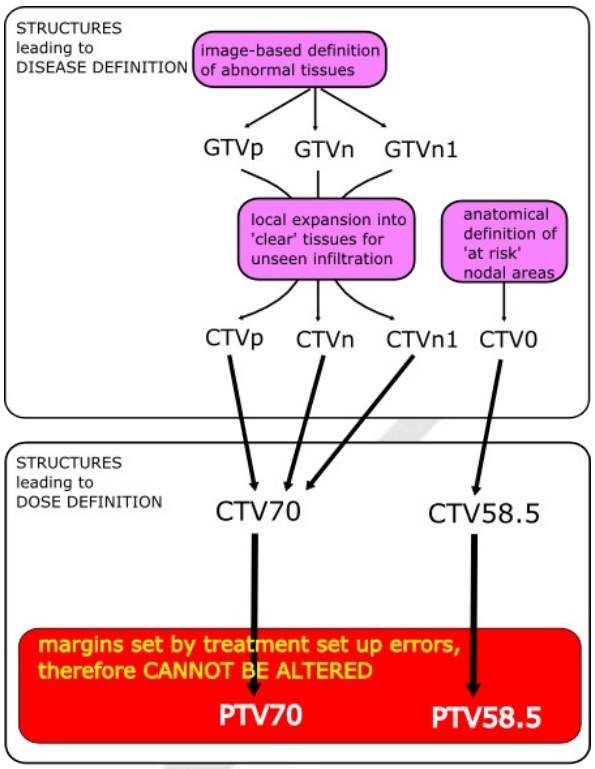
No expansion required in CTV grouping.
The CTV70 etc volumes can be removed after use.



IMRT Planning

- The treatment plan assessment for each patient will be based on an analysis of the volumetric dose, according to the dose volume histogram (DVH) which visualizes dose deposition in the PTV and critical normal structures.
- The method used for tissue heterogeneity calculations shall be reported.
- The definition of volumes will be in accordance with the 1993 ICRU Report #50: *Prescribing Recording and Reporting Photon Beam Therapy* and 1999 ICRU Report #62: *Prescribing, Recording and Reporting Photon Beam Therapy* (Supplement to ICRU Report 50).

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Normal Tissue Contours (Critical Structures) (See H&N atlas)

- IV contrast is used during simulation to define the vessels and nodes.
- All tissues to be irradiated must be included in the CT scan. CT scan thickness should be 0.2 cm throughout the entire scan length. The superior limit will be at least at least 2 cm above the pinna to 4 cm below the suprasternal notch.
- The GTV, CTV and PTV and normal tissue contours must be produced on all CT slices in which the structures exist on the full-bladder scan. All normal tissues will be produced on all CT slices in which the CTV exist and on at least 10 slices above and below the target, i.e., outside the PTVs.
- Normal tissue organs will be contoured on the planning CT scan.
  - *definition*
    normal structures at risk of radiation damage at the nominated dose will be outlined
  - *delineation*
    the structures will be assessed by the radiation oncologist as adequately defining the organ
  - *extent*
    - Organ outline
      the organ will be defined within a contour called **organ**.
      Laterality will be indicated by **organL** or **organR**
    - Organ exclusion
      for the purposes of planning, the section of the organ to be spared will be included within an exclusion contour called **organ_PRV**. This PRV is constructed manually but preferably automatically by defining the portion of the **organ** volume that exists more than 7mm from the PTV as **organ_PRV**.
      - CRITICAL NORMAL ORGANS
        These entire organs need to be **excluded** from receiving a harmful dose (e.g., spinal cord). These PRV expansions **cannot be altered to make a subsequent DVH look "acceptable"**.
      - NORMAL ORGANS
        These organs are expected to receive some dose and so the aim of definition is to identify the partial volume which can be spared because it is sufficiently distant from the PTV. These PRVs can therefore be altered and even ignored for the sake of PTV coverage.
  - **Dose constraints**
    The dose constraints for normal tissue contours will be defined as maximum doses within the **organ_PRV**, rather than fractional DVH values (e.g., 50% < 26Gy). The area between the **organ_PRV** and **PTV70** is required for dose deposition, will always get total dose and so plays no role in assessing plan acceptability, and can be kept to 5-7mm as a minimum to promote optimal dose sculpting.

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Appendices

Appendix 1: **IMRT Planning Objectives**
Appendix 2: **Head & Neck specific IMRT instructions**
Appendix 3: **Pelvis specific IMRT instructions**
Appendix 4: Brain

I shall maintain the editable copy of this document. Please mark your PDF print out for matters that you wish to discuss at our meetings.

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Appendix 1: IMRT Planning Objectives

Oncologist	**KFoo CFox AMiller LNasser**			
Planners				
PTVs defined	PTV___	PTV___	PTV___	
Acceptable coverage is 95-107%	PTV___	PTV___	PTV___	

Organs at Risk & PRVs	**max dose (Gy)**	**mean dose**	**Dose achieved**	**Comments**
Parotid R PRV	18			
Parotid L PRV	18			
Submandibular R PRV	18			
Submandibular L PRV	18			
Mucosa PRV	40			
Midline Structures	40			
Lens R	10			
Lens L	10			
Eye R	25			
Eye L	25			
Optic nerve R	45			
Optic nerve L	45			
Optic chiasm	45			
Brain PRV	45			
Spinal Cord (0.1mL max dose)	45			
Brainstem	45			
Cochlea	45			
Mandible				
Lacrimal gland				
Skin				

Trial Name		**Revision Number**	
Comments			
Radiation Oncologist	___/___/___	**Physics Contour check**	___/___/___
Physics On-screen check	___/___/___	**Physics QA**	___/___/___

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Appendix 2: Head & Neck specific IMRT instructions

1. **Defining the relevant nodal stations**
   The nodal groups to be considered include Level I to VI lymph nodes. The nodal CTV is initially identified by the vessels and then is manually enlarged to include the perivascular tissues which contain the nodal tissues. The nodal CTV in the N0 neck (CTVn0) extends:
   1.1. laterally to abut the sternomastoid muscle and the inferior mandibular fascia
   1.2. medially to abut the deep muscles of the neck
   1.3. anteriorly to include the vascular structures (internal carotid & jugular vessels)
   1.4. posteriorly may end at the posterior border of the sternomastoid
   1.5. superiorly, the nodal CTV may extend into the retropharyngeal nodes anterolateral to the body of C1/2
   1.6. special issues
      1.6.1. **level I** is only at risk for lesions of anterior chin/lower lip
      1.6.2. if **level Ib** is not at risk, CTVn0 should exclude the submandibular gland with a small 3mm margin and no extension anterior at this level
      1.6.3. if **level V** is not at risk – stop volume at posterior sternomastoid
      1.6.4. **level VI** is only at risk in special circumstances

2. **Defining the Planning Target Volume (PTV)**
   2.1. The PTV constructed by **software expansion uses a** 3mm **symmetrical margin** (anteriorly, posteriorly, laterally, superior and inferior directions) around CTVs

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3. **Normal Tissues**

The following normal structures will be contoured on the full-bladder CT scan

3.1. **Salivary/Lacrimal Glands**

The entire gland outline will be produced.

3.2. **Central Nervous System structures**

The entire structure will be produced across the extent of the treated field.

3.3. **Bones**

The mandible and petrous bone may be outlined in cases where Osteonecrosis is thought to be a risk, or where deafness must be deliberately guarded against.

3.4. **Midline Aerodigestive Structures**

In order to spare the mucosa or larynx, it is necessary to outline these structures.

3.4.1. the mucosa can be outlined an the air-containing structure (auto-threshold), or as a 2mm annulus around this air-tissue interface

3.4.2. the larynx should be volumed to include the laryngeal cartilage

3.5. **Dose constraints**

Dose constraints can apply to whole organs (CNS organs, lacrimal gland) or to PRVs (all other organs). PRVs are defined as the portion of the normal structure residing more than 7mm from the lowest dose PTV. IMRT is used to spare dose to the portion outside the PTV and penumbral area only.

Organ PRV	**Dose Constraint (PRV structure)**
3.6. **Glands**	
3.6.1. Parotid glands	<18Gy
3.6.2. Submandibular glands	<18Gy
3.6.3. Lacrimal glands	<10Gy
3.7. CNS	
3.7.1. Spinal Cord	<45Gy
3.7.2. Brainstem	<45Gy
3.7.3. Optic Apparatus (optic chiasm, optic nerves, eyeball and lens)	<45Gy <5Gy (lens)
3.8. **Midline Aerodigestive Structures** (these are defined specifically as PRV structures)	
3.8.1. Mucosa	<40Gy
3.8.2. Larynx	<40Gy
3.8.3. Tongue	<40Gy
3.9. **Bone** (defined specifically as PRV structures)	
3.9.1. Mandible	<50Gy
3.9.2. Inner Ear	<40Gy

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Appendix 3: Pelvis specific IMRT instructions

1. **Defining the relevant nodal stations**
   The nodal groups to be considered reside among the pelvic vessels. Voluming should therefore begin with identification of the vessels. The volume is then manually enlarged to include the fatty perivascular tissues which contain the nodal tissues, excluding the bones, muscles and contents of the peritoneal cavity (bowel). Note that this volume is therefore highly idiosyncratic.
   1.1. the **presacral nodes** are defined as the retroperitoneal tissues in a triangle between the common iliac vessels down to the level of S3
   1.2. the **external iliac node** risk can vary and where the decision is made to exclude the external iliac nodes from treatment, the nodal volume should not extend out of the bony pelvis as determined by a line between the most anterior bone extent
   1.3. the **bifurcation of the aorta** is traditionally the marker that includes all the common iliac nodes, Although this was described as being at the L5/S1 junction, voluming reveals this to be too low in most cases. Therefore an explicit decision should be made to either volume to the L5/S1 junction or up to the bifurcation in each case.

2. **Defining the central CTV**
   The central disease in the pelvis is not attached to the bony structures and so is subject to the displacement effects of bowel and bladder filling. As per the protocol, the patient will be instructed to drink 2 glasses (500mL) of fluid 45 minutes before simulation.
   2.1. **initial CT scan** with full bladder and no contrast to establish the image set for planning
   2.2. **second CT scan** with empty bladder and IV contrast to establish the extent of movement with bladder change and delineate vessels.

3. **Defining the Planning Target Volume (PTV)**
   The PTV constructed by **software expansion uses a 7mm symmetrical margin** (anteriorly, posteriorly, laterally, superior and inferior directions) around CTVs
   3.1. Measurements of bony displacement on treatment films should be recorded and fed back to illuminate the required expansion.

4. **Normal Tissues**
   The following normal structures will be contoured on the full-bladder CT scan.
   4.1. **Bladder**
   The entire bladder outline will be produced.
   4.2. **Rectum**
   The 'entire' rectal outline will be produced, extending superiorly to end at the slice below where the rectum can perceived as starting to turn anteriorly into the rectosigmoid.
   4.3. **Small Bowel**
   The 'small bowel' outline comprises all other intestinal contents (large or small) seen on the scan. The outline will be produced on every slice beginning 2 cm superior to the first PTV mark. The volume marked matches abdomino-pelvic cavity marked by the edge of the peritoneum within which the bowel lies at any time throughout the course of treatment. Distally this volume should extend to the rectosigmoid junction.
   4.4. **Femoral Heads**
   The femoral heads should be autocontoured down to the superior portion of the lesser trochanter.
   4.5. **Dose constraints**
   Dose constraints can apply to whole organs (femoral heads) or to PRVs (all other organs). PRVs are defined as the portion of the normal structure residing more than 7mm from the lowest dose PTV. IMRT is used to spare dose to the portion outside the PTV and penumbral

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area only.

Organ PRV	Dose Constraint (PRV structure)
3.10.Bowel	
3.10.1.Rectum	<18Gy
3.10.2.Small Bowel	<18Gy
3.11.Bladder	
3.12.Femoral Heads	

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Appendix 5: HOWTO mark up volumes/contours sequentially

When the radiation oncologist comes to volume the CT dataset/s, there will be a list of image names already pre-defined and available. For future analysis it is important that these names remain unchanged. The oncologist may add additional names if required, and may delete unused names.

1. PRIMARY
    a. mark the abnormality on the CT scan corresponding to the PRIMARY
    b. label GTVp
    c. expand by 3mm and label CTVp
    d. post-op cases have the operative bed marked and labeled CTVp

2. INVOLVED LYMPH NODES
    a. mark the abnormalities on the CT scan corresponding to INVOLVED LYMPH NODES
    b. label GTVn
    c. expand by 3mm and label CTVn

3. N0 LYMPH NODES
    a. Identify and mark the blood vessels
    b. Label *CTV0*
    c. Expand to the anatomical boundaries limiting the perivascular fat
        i. PELVIS: not into bowel, muscle or bone
        ii. H&N: not into parotid, muscle, thyroid, or bone
    d. Exclude clinical disease from non-clinical disease
        i. Copy *CTV0*, exclude CTVp and CTVn to form CTVn0

4. DEFINE DOSE REGIONS
    a. [CTVp + CTVn; all macroscopic disease] + [3mm; IGRT movement] = PTV70
    b. [CTVp + CTVn + CTVn0; all tissue at-risk] + [3mm; IGRT movement] = PTV60

5. DEFINE IMRT SHAPER FOR OARs EXCLUSION
    a. PTV60 + 7mm = PTV_PRV

6. DEFINE CONTOURS
    a. Mark anatomical structures using listed names
        i. Mucosa
        Suggestion: use the autocontour tool to outline the air cavity to form mucosa
        contract mucosa by 1mm to form mucosa_contract
        expand mucosa_contract by 3mm to form mucosa_expand
        copy mucosa_expand excluding mucosa to form mucosa wall
        delete mucosa, mucosa_contract and mucosa_expand
    b. Delete unused anatomical structures
    c. Define the Planning Risk Volume (PRV) for each organ
        i. Critical EXCLUSION organs (e.g., spinal cord, neural tissue)
        [ORGAN] + [3mm; IGRT movement] = ORGAN_PRV
        ii. Organs requiring dose MINIMISATION
        [ORGAN] + [3mm; IGRT movement] – PTV_PRV = ORGAN_PRV

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