

RT-PRO-253

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Radiotherapy Protocol for Operable Invasive Breast Cancer (T1/T2/T3a N0N+ M0)

UK

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1. Introduction and Purpose

GenesisCare is committed to delivering its strategic and operational objectives in accordance with all applicable legislation, standards, and principles of good governance.

To describe the process for the prescription standards for breast radiotherapy (RT) at GenesisCare.

2. Scope

2.1 General considerations

- All fit patients should have definitive surgery prior to RT.
- Marker clips should be placed to locate the tumour bed before the start of neoadjuvant chemotherapy (NACT).
- All patients with invasive early breast cancer should have a preoperative ultrasound examination of the axilla and subsequent ultrasound guided nodal biopsy when indicated.
- Patients with a histologically and radiologically negative axilla should have sentinel lymph node biopsy performed.
- Management of the pre-operative positive axilla is controversial and there is currently no consensus. Patients with a positive lymph node identified pre-operatively (or up to 2 nodes) may not need further axillary treatment if the histology is otherwise favourable [1] or may receive axillary treatment with axillary dissection or axillary radiotherapy [2].
- Involvement of a surgical margin (<1mm) other than the anterior or posterior margin requires MDT discussion. Further surgery to achieve clear margins is usually recommended.
- Radiotherapy should start after chemotherapy, where applicable.
- Primary radiotherapy may be indicated for Inoperable or Palliative cases.

3. Adjuvant Whole Breast Radiotherapy (WBRT)

Adjuvant Radiotherapy (RT) improves local control and survival. RT after breast conserving surgery (BCS) halves the rate at which the disease recurs and reduces Breast cancer death by about a sixth. Overall, one Breast cancer death was avoided by year 15 for every four recurrences avoided by year 10 [3].

3.1 Clinical Indications:

- WBRT is usually indicated after BCS.
- WBRT may be omitted in low risk patients with invasive breast cancer and ALL of the following [4]:
- Age \geq 65 years
- Had BCS with clear margins
- Very low absolute risk of recurrence: T1N0, ER positive, Her-2 negative and willing to take adjuvant endocrine therapy for a minimum of 5 years
- Where the patient's performance status makes radiotherapy impractical.

3.2 WBRT – Prescriptions & Planning

- Technique: Planning CT scan to be undertaken in free breathing. An additional DIBH scan will be performed for patients deemed suitable for breath hold technique. Generally, no additional diagnostic images are required for planning. For breast-only tangents: scan from lung apices to bottom of lungs. For SCF inclusion: scan from mastoid to lung bottoms. There is no need for denture removal.
- In women with previous contralateral radiotherapy a 1 cm gap to previous medial border is recommended to minimise/avoid overlap with previous treatment.
- Dose and fractionation: Standard dose-fractionation for WBRT is hypofractionated to a dose of 40.05 Gy in 15 daily fractions over 3 weeks using tangential fields [5].
- Fast-Forward (FF) trial compared 40.05 Gy in 15 daily fractions versus 26 Gy in 5 daily fractions or 27 Gy in 5 daily fractions[6]. Fast-Forward 5-year local relapse data have now been published showing non-inferiority of the 26 Gy/5F fractionation versus the standard 40Gy/15F protocol.
- UK Breast Cancer Group has issued a national statement (in March 2020) recommending consideration of shortening fractionation to 26 Gy in 5 fractions when appropriate in light of Covid-19 pandemic and many NHS RT centres have adopted this.
- Fast-Forward fractionation (26 Gy in 5 daily fractions) is a reasonable alternative for WBRT or Post-mastectomy radiotherapy (PMRT) in node negative patients or node positive when there is no indication for nodal irradiation. Clinician judgement is required to decide if FF is appropriate after extensive mastoplasty or chest wall reconstruction. A sequential boost is acceptable following FF trial hypofractionation and the

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recommended dose is 10Gy in 5 fractions, but other alternative fractionations are acceptable (see Tumour bed boost section).

- When a tumour bed boost is indicated then standard fractionation of 40.05 Gy in 15 daily fractions with Simultaneous Integrated Boost (SIB) is recommended.
- Clinicians are referred to the FF trial protocol regarding planning constrains and Organs at Risk (OARs) tolerances when 26 Gy in 5 fractions is used. Tolerances according to fractionation size extracted from Fast-Forward trial protocol is pasted below for reference.

Control Group

- The volume of ipsilateral lung receiving 12.0 Gy should be less than 15%
- The volume of heart receiving 2.0 Gy and 10.0 Gy should be less than 30% and 5% respectively.

Test Group 1 and 2

- The volume of ipsilateral lung receiving 8.0 Gy should be less than 15%
- The volume of heart receiving 1.5 Gy and 7.0 Gy should be less than 30% and 5% respectively.

Dose per fraction (Gy)	Keep 30 % of dose to < 15 % of ipsilateral lung volume	Keep 25 % of dose to < 5 % of heart volume	Keep 5 % of dose to < 30 % of heart volume
2.67	12.0 Gy	10.0 Gy	2.0 Gy
5.2/5.4	8.0 Gy	7.0 Gy	1.5 Gy

From Protocol Version 3.0) the dose to the ipsilateral lung and heart from the composite plan should be kept as low as reasonably achievable.

- Fields: tangential fields ensuring covering of Breast tissue with a minimum of 0.5 cm margin. Maximum central lung depth (CLD) of 1.5-2.0 cm. Aiming for no heart in field with routine use of DIBH in all left sided Breast cancers.
- N.B CLD metric is a guide for field placement and extent, OAR DVH constraints should be prioritised as plan quality metrics. In cases of high CLD or high DVH stats, the referring clinician should be consulted to steer decisions on OAR sparing and coverage compromise.
- Energy: usually 6 MV but mixed or higher energy may be needed depending on the separation.

4. Tumour Bed Boost

Boost to the tumour bed can improve local control but has no effect in long term survival. The largest absolute benefit is seen in young patients. The HR reduction of ipsilateral tumour recurrence was 0.65 but it does increase the risk of moderate to severe fibrosis [7].

4.1 Clinical Indications

- Considered in selected women with Invasive Cancers.
- Considered in most women age ≤ 50 years with Invasive cancer.
- Considered in women > 50 years with Invasive cancer with any of the following high-risk features:
 - Grade 3 histology
 - Extensive Intraductal component
 - Positive radial margin (defined as tumour at inked margin when there is no scope for further surgery)

The role of tumour bed boost after a pathological complete response to neoadjuvant chemotherapy (NACT) is unclear. It is acceptable to offer a boost in this clinical situation.

4.2 Tumour bed boost – RT planning

The tumour bed should be outlined using the operation note and surgical clips to define CTV TB.

PTV TB: CTV TB + 5-10 mm

A variety of radiotherapy techniques may be used in the delivery of a tumour bed boost.

- Simultaneous Integrated boost (SIB) has emerged as the preferred technique to achieve optimal dose distribution and shortening of treatment time. A higher dose per fraction in a tumour with low α/β ratio has the potential to increase tumour control and at the same time reduce the overall treatment time for patients.
- Sequential boost – Electrons: dose usually 16 Gy/8 fractions (or equivalent EQD2 e.g.: 13.35 Gy in 5 fractions) or 10 Gy/5 fractions (or equivalent EQD2 e.g.: 10.5 Gy in 3 fractions). Electron energy chosen to cover skin to fascia/chest wall distance. Other acceptable boost doses: 12Gy/4#, 9Gy/3#, 10.5Gy/3#, 12.5Gy/5#.
- Sequential boost- Photons: 16 Gy in 8 fractions or 10 Gy/5 fractions or equivalent fractionation as above. It is recommended to use fraction size of 2 – 2.67 Gy to minimise long term fibrosis given a

significant proportion of breast tissue is usually treated when using mini-tangential beams. DIBH scan could be used minimising lung/heart as appropriate.

- 48Gy/15# with 0.5cm CTVboost margin to make PTVboost (CTVboost delineation guided by the scar, surgical clips, pre- and postoperative radiological breast changes, surgical report).
- Technique: SIB delivery is based on a combination of breast IMRT tangents to cover the 40Gy whole breast dose and a single VMAT partial arc to cover the 8Gy boost (T-VMAT).

Dose parameters: The optimization prescription aims to deliver at least 92 % of the prescribed dose to 95% of the target volume and to minimise the volume that receives >107% of the boost dose. For the OARs, a mean dose <5 Gy to the heart for left sided cases, <3 Gy for contralateral breast and lung, a V20 below 22 % for ipsilateral lung should be achieved [8].

5. Partial Breast Irradiation

5.1 Rationale

The majority of local breast recurrences occur near the tumour bed. Published evidence suggests there is a role for Partial Breast Irradiation (PBI) in selected patients.

The IMPORT Low trial demonstrated non-inferiority in terms of ipsilateral local relapse for (PBI) in comparison with Whole Breast Irradiation (WBI) [9]. PBI showed equivalent or fewer normal tissue late adverse events. The fractionation used in this trial was 40Gy / 15 fractions to the Partial Breast, or 36Gy / 15 fractions to the Whole Breast with 40Gy/15 fractions to the Partial Breast volume. Although eligibility criteria included all histological grades and nodal status, only 10 % of patients had grade 3 histology and only 4 % of patients were node positive. As the risk of local recurrence beyond 5 years is not yet known, it is recommended to follow NICE [4] or RCR criteria [10] to select patients for PBI. Given there was no difference in local control with the 2 fractionations used in the study, but 40Gy in 15 fractions to Partial Breast offers the least side effects, this is the proposed fractionation for this technique. It is anticipated the 10-year follow-up update will be available in 2020.

Recent national RCR Consensus agreed that FF fractionation of 26 Gy in 5 fractions could also be used for PBI.

Other trials have investigated the role of Accelerated Partial Breast Irradiation (APBI). A published phase 3 randomised trial compared WBI with APBI using IMRT [11]. The fractionation used in this trial was 30Gy in five alternate days. The WBI arm received 50Gy / 25 fractions, followed by a boost to the tumour bed of 10Gy / 5 fractions. After 10 years of follow-up, 3.3% of patients in the APBI group had

experienced a recurrence of breast cancer compared to 2.6% in the group that received WBI with no difference in overall survival between the two arms. APBI displayed a significantly better toxicity profile than the WBI group.

5.2 Patient selection

- PBI should be considered (as an alternative to Whole-Breast radiotherapy) in the following patients [4]:
 - Women aged ≥ 50
- Treated with Breast Conserving surgery for unifocal Invasive Ductal Carcinoma (Invasive Lobular histology are excluded from PBI)
- Tumour size of ≤ 3 cm (pT1-2)
- Grade 1- 2
- Node negative
- ER positive
- Her-2 negative
- ≥ 2 mm margin (DCIS) or ≥ 1 mm margins (invasive).

5.3 RT planning

PBI requires careful definition of the target volume to avoid geographical miss, as margins are reduced. Reconstruction of "tumour bed" is considered the ideal approach but it is not always easy to be certain of the "tumour bed" location post-operatively. In this scenario clinicians may opt to define "surgical bed" instead.

It is recommended Partial Breast volume should not be $>30\%$ of the total breast volume to be able to gain reduction of long-term toxicity. However, the proportion of breast tissue irradiated is less crucial if standard fractionation is used, as opposed to APBI. Therefore, it is important not to offer Accelerated PBI if the tumour bed volume is $>30\%$ of total breast.

5.4 Tumour bed localization

To define the "tumour bed" clinicians are advised to refer the new GEC ESTRO Breast cancer working group guidelines [12].

Clinicians may encounter at least 3 scenarios after breast conserving surgery:

- Visible seroma cavity (Open cavity technique)
- Non-visible seroma (Closed cavity technique)

Oncoplastic procedure: It is a special form of closed cavity surgery, usually associated with removal of large tumours and breast reconstruction with

mobilisation of tissue. There is no consensus about surgical clips placement in these cases and clips may be found on different quadrants. It is anticipated few patients with low-risk disease will require oncoplastic surgery, but it is an option for patients with small breasts. Clinical judgement is needed to identify relevant clips marking "tumour bed" and to be able to ignore others far from tumour location.

It is recommended clinicians have knowledge of the surgical technique used to be able to delineate the "tumour location" before breast conserving surgery and to translate this information to planning CT.

To use "tumour bed" localization clinicians need to define surgical clips, whole surgical scar (WS) inside the breast and delineate the imaging correlated target volume (ImTV) based on mammogram, ultrasound, and MRI. These three factors are then used to define Estimated Tumour Bed (ETB).

Usually a margin of 20 mm is added to the ETB to define CTV-Partial Breast (PB). If histology report is available detailing all margins (mm), then specific margins could be deducted from standard margin to create an "adapted safety margin," ensuring at least 10 mm. For example, a superior histological margin of 3 mm means an ETB to CTV margin superiorly of 17 mm (20 mm minus 3 mm).
 $PTV-PB = CTV-PB + 10 \text{ mm}$. The CTV to PTV margin could be reduced to 5 mm if DIBH and daily CBCT are used.

The PTV PB volume could be treated using tangential fields, 3D-CRT or IMRT/VMAT technique for higher conformity and normal tissue sparing. If VMAT is used then DIBH is recommended, regardless of laterality.

5.5 Surgical bed localization - IMPORT Low Planning technique [13]

This technique is based on localisation of "surgical bed" using surgical clips. Surgical clips should be delineated and grown by 15 mm to give the CTV-PB, reduced by 5 mm from the skin surface and should not extend beyond the pectoral fascia posteriorly.

If the pectoral fascia is not visible, then it should be no more than 5 mm from the lung/chest wall interface.

$PTV-PB = CTV-PB + 10 \text{ mm}$; this is bound by 5 mm from the skin surface but unmodified posteriorly.

This volume is treated using standard tangential fields with an optimised 3D-CT plan

5.6 APBI – IMRT - Florence Study [11]

For this technique surgical clips are defined. CTV APBI; surgical clips + 1 cm.
 $PTV APBI: CTV APBI + 1 \text{ cm}$, from 3 mm from skin and 4 mm from Lung.
The APBI volume is treated using IMRT/VMAT planning technique.

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OARs tolerances need to be adjusted to fractionation [11]:

- Contralateral Lung V5 <10%
- Ipsilateral Lung V10 <20 %
- Heart V3 < 10%
- Ipsilateral Breast V15 < 50%
- Contralateral Breast < 1Gy

5.7 Doses

Partial Breast only 40.05 Gy in 15 daily fractions over 3 weeks, treating 5 days per week, 1 fraction per day, 2.67Gy/#. Alternative, 26 Gy in 5 daily fractions is also acceptable.

Accelerated PBI 30Gy in 5 alternate days is an alternative technique.

6. Post Mastectomy chest wall radiotherapy (PMRT)

RT after mastectomy reduced both recurrence and Breast cancer mortality in women with node positive disease. In patients with 1-3 positive nodes, RT reduced Breast cancer mortality by 20% (RR 0.80; 2p 0.01) and for >4 nodes by 13 % (RR 0.87; 2p 0.04) [14]

6.1 Absolute Clinical indications – Offer PMRT

- Node positive (macrometastases) [4]. Particularly tumours ≥ 4 nodes involved (chest wall plus regional nodes)
- Involved resection margins (RT to chest wall only) [4]
- Consider in T3/T4 disease.

6.2 Relative Clinical indications:

- Node positive tumours 1-3 nodes involved (chest wall and consider regional lymph nodes).
- Node negative tumours with high risk factors (multifocal disease, adverse receptor status, large tumour in smaller breast, grade 3 histology, widespread lymphovascular invasion) The SUPREMO trial results are awaited to guide practice in this group of patients.
- Post neoadjuvant chemotherapy (including supraclavicular fossa if node +ve)

The selection of patients requiring PMRT after NACT remains unclear but is based on the baseline disease extent and response to NACT. The results of NSABP B51/

RTOG1304 on the role of PMRT in patients converted from node positive to node negative are awaited and will better define practice.

6.3 Post-mastectomy chest-wall radiotherapy (PMRT) – Prescription & Technique

The preferred dose-fractionation for PMRT is hypofractionated to a dose of 40.05 Gy in 15 daily fractions using tangential fields. Alternatively, 26 Gy in 5 daily fractions is also acceptable.

7. Supraclavicular (SCF) Radiotherapy

7.1 Clinical Indications:

- Is indicated for N2 tumours (≥ 4 nodes involved) or where the percentage of positive nodes may have been influenced by the extent of the axillary dissection.
- Can be considered for tumours with 1-3 nodes involved and high-risk factors (e.g. young patients with triple negative cancers).
- Following NACT (Neoadjuvant chemotherapy) for positive axillary disease at presentation (after axillary dissection or with axillary RT).

8. Radiotherapy to Axilla

8.1. Clinical Indications:

- Axillary radiotherapy is not indicated for node negative breast cancers.
- Axillary radiotherapy may be appropriate in the undissected/node positive axilla, where no further surgery is planned.
- If the sentinel node(s) shows isolated tumour cells and/or micrometastases no further axillary treatment is required in addition to breast conserving surgery or mastectomy.
- With macrometastases in 1-2 sentinel nodes further axillary treatment is no longer mandatory in patients who are receiving breast conservation with WBRT, postmenopausal and have T1, grade 1 or 2, ER positive and HER2 negative tumours.
- If 1-2 sentinel nodes are involved, axillary radiotherapy can be an alternative to axillary clearance.
- Level 1-3 nodal irradiation is indicated for tumours with positive nodes on sentinel node biopsy where no further surgery is planned[15].

8.2 Radiotherapy to the axilla – RT planning Techniques

For conformal plans, axilla is usually treated with a single anterior beam. However, for some patients with large separation it is necessary to add an axillary posterior beam to achieve adequate coverage.

If axilla is treated as part of wider regional nodal irradiation, including IMC then full ESTRO guidelines contouring [16] is recommended and volume planned using a VMAT technique.

9. Internal Mammary Chain (IMC) nodal irradiation

9.1 Clinical Indications

- Recommended for tumours with radiological and/or pathological evidence of IMC node involvement, even after a radiological complete response to NACT [10].
- Should be offered if ≥ 4 nodes positive (N2/N3), and/or T3/T4 medially located tumours
- Should be considered in patients with 1-3 axillary macro-metastases who have been recommended loco-regional irradiation based on risk factors AND medially located tumours and favourable risk/benefits and favourable risk/benefits (e.g. no previous contralateral RT, no lung comorbidities, suitable for DIBH).

Irradiation of the IMC will increase the contralateral breast and lung dose. There is an increased risk of pneumonitis which is an important clinical consideration at the time of consenting.

9.2 RT planning

- Target coverage: Clinician judgement should be applied to decide target dose, and this should be clearly documented in planning request form. For patients with proven IMC nodal involvement a higher target may be desirable (e.g.: 90% of the IMC CTV should be covered by 90 % isodose) [17]. However, 80% IMC CTV coverage may be acceptable for prophylactic nodal irradiation [18].
- A cardiac sparing technique is offered routinely when treating IMC nodes, irrespective of laterality.
- CTV is drawn <5mm from the skin surface, coverage of this region will not be obtained without the use of dedicated bolus. Need for physical bolus should be discussed with the clinician if appropriate and it is usually applied to midline.

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- Use MIM OAR and Breast Nodal ROI workflows to create suggested CTVs. ESTRO consensus guidelines [16] are to be used to support editing and optimisation of target ROIs.
- As the VMAT beam is likely to enter through the couch this needs to be modelled in Pinnacle. Please refer to GenesisCare Planning Notes PHY-MAN-101.

Techniques:

- Wide tangential fields: IMC irradiation may be achieved through the use of wide tangential fields, usually crossing midline to cover first 3 ipsilateral intercostal spaces (to the top of 4th rib) [18, 19]. Exceptionally there is need to cover the first 4 Intercostal spaces (very low tumour in the lower inner quadrant or low IMC nodal involvement).
- Full VMAT plans: More advanced/complex RT techniques using VMAT offer better conformality and dosimetry. Full ESTRO contouring [16] is mandatory for this technique.
- ESTRO guidelines should be used for nodal volume delineation [16]:
 - The IMC vessels (vein and artery) are defined over the first 3 intercostal spaces. A margin of 0.5 cm is added to create a CTV IMC (restricted from bone/sternum and pleura/lung)
 - Levels 1, 2, 3, 4 and interpectoral nodes (as indicated) and breast / chest wall CTV are outlined.
 - The CTV IMC is combined with the nodal and breast / chest wall as appropriate to create a CTV final.
 - PTV final: CTV final + 0.5 mm.
 - OARs are contoured (contralateral breast, lungs, heart, humeral head + 1cm and oesophagus and trachea).
- Where IMC is included in the target volume, the following constraints are recommended:
 - Ipsilateral lung V17 < 35 %
 - Heart V17 < 10%
 - -Mean contralateral breast dose < 3.5Gy
 - In patients at intermediate risk, a mean heart dose of < 6 Gy is considered a reasonable objective (RCR guidelines)
- Reproducible arm positioning that is away from the VMAT beam, is required
- Isocentre can be placed sup to laser localisation level if treating SCF nodes using single VMAT beam. In other instances, a separate

'imaging isocentre' can be used. This will help avoid doing multiple kV imaging.

10. Postoperative radiotherapy for ductal carcinoma in-situ (DCIS)

10.1. Clinical indications

- Consider adjuvant RT for DCIS after BCS with clear margins, taking into consideration benefits and risks [4].
- Endocrine therapy should be considered for ER positive DCIS when RT was recommended but not received, or RT not recommended [4].
- The MSKCC DCIS risk prediction tool is a useful tool when discussing DCIS with patients [20].

11. Other treatment consideration

11.1. Re-irradiation

There may be situations where re-irradiation is considered after a very long interval. Cases for re-irradiation should be referred to the clinical advisory team as per the Clinical Advisory Team Policy (RT-POL-136).

11.2. Palliative RT for locally advanced/inoperable disease

Full dose and fractionation for WBRT (+/- boost) may be considered for local control, but more commonly the clinical situation would favour 1 or 2 fractions per week, large dose per fraction (5-6 Gy), over a short time (30-36Gy). Other acceptable doses: 27Gy in 6 fractions, three times weekly over two weeks, or 28.5Gy in 5 fractions, weekly over five weeks.

11.3. Palliative Radiotherapy for metastatic sites

11.3.1. Bone metastases

Palliative radiotherapy for bone metastases should follow the same protocol as other tumour sites. 8Gy single fractions are preferred for most cases with short fractionated courses for spinal cord compression, for example 20 Gy in 5 fractions.

Alternative fractionations include 30Gy/10#.

Re-treatment or bone/spinal metastases with Single fractions may still work but leaving flexibility for a short-fractionated course if spinal cord in field would also be appropriate.

11.3.2. Brain metastases

Stereotactic Radiosurgery (SRS) should be considered, if possible, for small number of lesions. It is advisable to refer the case to the Neuro-Oncology MDT. For whole brain radiotherapy 20Gy in 5 fractions is commonly used. If patient has a very good performance status and systemic disease is controlled perhaps consider a higher dose e.g. 30Gy in 10 fractions.

11.4. Oligometastatic Disease

Patients should be considered for SABR and referred to the SABR MDT.

12. RT Planning Techniques and methods

Pre-treatment imaging guidelines and setup procedures are all defined within:

- Molecular Imaging and Diagnostic Imaging Operations Policy and Patient Pathway's (DIA-POL-358)
- Align RT Workflows Breast Chest Wall (RT-WI-249)
- Align RT Workflows Breast Chest Wall DIBH (RT-WI-250)
- Align RT Workflows Breast Chest Wall DIBH with bolus (RT-WI-294)
- Align RT Workflows Breast Chest Wall with bolus (RT-WI-295)

For practical guidance/working instructions on planning each breast treatment variant, please refer to the Pinnacle Breast Plan Preparation Work Instruction (PHY-WI-102).

12.1. Whole breast radiotherapy (WBRT)

Immobilisation as per CT set up sheet (RT-TEM-387).

Site	Immobilisation Device	Set-up	Suggested practice	Localisation	Tattoo/ Reference Mark Location
Breast Tangent only & Tangent/ nodal involvement	Breast board at 10 or 12.5 degree angle; knee fix	Supine, head to gantry, both arms above head (if achievable); if nodal involvement head kept central	Mandatory AP/ Lat Mosaik set-up photograph (Tattoo location visible. All CT wire removed); Multiple landmark measurements; Scar to be marked for scan; Clothing & jewellery removed as necessary	Tangents only: Superior to apex of lung and inferior to diaphragm and greater than 5cm from inferior breast tissue Tangent & Nodes: EAM to inferior of diaphragm and greater than 5cm from inferior breast tissue	Anteriorly on m/l at approx. half of tangent length Lt & Rt Lat rotation tattoos at approx. post edge of beam

- Technique: If approach is permitting, planning CT scan to be undertaken in free breathing. An additional DIBH scan will be performed. Generally, no additional diagnostic images are required for planning. For breast-only tangents: scan from lung apices to bottom of lungs. For SCF inclusion: scan from mastoid to lung bottoms. There is no need for denture removal.
- Fields: tangential fields ensuring covering of Breast tissue with a minimum of 0.5 cm margin. Maximum lung depth of 1.5 cm. Aiming for no heart in field with routine use of DIBH in all left sided Breast cancers and the use of MLC shielding.
- Energy: usually 6 MV but mixed or higher energy may be needed depending on the separation.
- DIBH will be used in patients treated with 26 Gy in 5 fractions if tolerated.

12.2. Deep Inspiration Breath Hold (DIBH)

DIBH is offered to all breast cancer patients.

DIBH is indicated for IMC RT, SIB RT, Partial Breast RT and in cases of large breasted women (large separation) in order to achieve dose homogeneity and reduce the dose to the right lung and liver.

Patients who have successfully completed the breath hold training may continue to CT under DIBH; Refer to CT set-up sheet (RT-TEM-387).

12.3. Consent

As per Patient Identification Procedures for Radiotherapy (RT-SOP-003).

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12.4. Bolus

Cases where a bolus is required for coverage at superficial areas, the referring clinician should make this information known at the time of the referral. In all cases where this information is not supplied, an affirmative query should be sent by the local treatment centre and documented on MOSAIQ, specifying bolus thickness, and intended coverage area.

To ensure accurate bolus placement, cases planned with VMAT or with custom bolus, a bolus setup field will be created by the planner and exported to MOSAIQ. With the patient positioned at isocentre, the light field projection of these setup fields will define the bolus borders and extent.

Bolus may be considered for PMRT, even for 26Gy in 5 fractions, in selected cases if clinician considered it appropriate (e.g.: skin involvement).

12.5. Patients with large/pendulous breasts

For patients with large/pendulous breast, consider all techniques utilising an additional lung avoiding, ANT oblique field, or a combination of tangents with a single VMAT arc to achieve dose homogeneity. These patients should be scanned in breath hold regardless of laterality and patient selection should be clearly stated on referral.

12.6. Scheduling of Patient Treatments

MPE to review patient criteria of all 26 Gy in 5 fraction treatments.

A five-working day CT to treatment planning pathway is standard pending clinician availability. Patients may start any weekday except Friday. Radiotherapy should ideally be started approximately 30 days after surgery and 3-4 weeks following completion of adjuvant chemotherapy, and CT planning may commence no more than 1-2 weeks before starting radiotherapy. Treatment breaks should be avoided wherever possible.

Where a break is unavoidable, dose compensation is not necessary.

Post-operative seromas are common after Breast Radiotherapy. As soon as the breast shape is not changing significantly then it is appropriate to proceed with planning to prevent delays. However, the presence of large seromas requiring repeated drainage or rapid changes in contour change it is likely more time is required before CT planning scan. Radiographers should liaise with appropriate clinician for advice.

12.7. Target and Dose Constraints for Organs at risk (OAR)

Target Volumes

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- GTV: GTV not applicable.
- CTVbreast: The Clinical Target Volume (CTV) is defined as the whole glandular breast tissue.
- ITV: ITV not applicable.
- PTVbreast

The PTV is defined as typically CTV+ 5 mm or the departmentally measured margin to account for, breathing, breast swelling & set up error. Alternatively, a PTV may be generated after field simulation.

- CTVchest wall

The CTV should include the deep fascia, subcutaneous tissue, and any remaining breast tissue.

- PTVchest wall

The PTV should be set using the following anatomical landmarks and taking into account locally derived CTV to PTV margins:

- Superior – 1.0cm superior to the position of the contralateral breast
- Inferior – 1.0cm below the inframammary fold of the contralateral breast
- Medial – the midline
- Lateral – 1.0cm lateral to the position of the contralateral breast

Breast contouring Atlas is recommended [16]:

ESTRO delineation guidelines for the CTV of lymph node regions, breast and postmastectomy thoracic wall for elective irradiation in breast cancer (see figures).

Borders per region	Axilla level 1 CTVn_L1	Axilla level 2 CTVn_L2	Axilla level 3 CTVn_L3	Lymph node level 4 CTVn_L4	Internal mammary chain CTVn_IMN	Interpectoral nodes CTVn_interpectoralis	Residual breast CTVp_breast	Thoracic wall CTVp_thoracic wall
Cranial	Medial: 5 mm cranial to the axillary vein Lateral: max up to 1 cm below the edge of the humeral head, 5 mm around the axillary vein	Includes the cranial extent of the axillary artery (i.e. 5 mm cranial of axillary vein)	Includes the cranial extent of the subclavian artery (i.e. 5 mm cranial of subclavian vein)	Includes the cranial extent of the subclavian artery (i.e. 5 mm cranial of subclavian vein)	Caudal limit of CTVn_L4	Includes the cranial extent of the axillary artery (i.e. 5 mm cranial of axillary vein)	Upper border of palpable/visible breast tissue; maximally up to the inferior edge of the sterno-clavicular joint	Guided by palpable/visible signs; if appropriate guided by the contralateral breast; maximally up to the inferior edge of the sterno-clavicular joint
Caudal	To the level of rib 4 – 5, taking also into account the visible effects of the sentinel lymph node biopsy	The caudal border of the minor pectoral muscle. If appropriate: top of surgical ALND	5 mm caudal to the subclavian vein. If appropriate: top of surgical ALND	Includes the subclavian vein with 5 mm margin, thus connecting to the cranial border of CTVn_IMN	Cranial side of the 4th rib (in selected cases 5th rib, see text)	Level 2's caudal limit	Most caudal CT slice with visible breast	Guided by palpable/visible signs; if appropriate guided by the contralateral breast
Ventral	Pectoralis major & minor muscles	Minor pectoral muscle	Major pectoral muscle	Sternocleidomastoid muscle, dorsal edge of the clavicle	Ventral limit of the vascular area	Major pectoral muscle	5 mm under skin surface	5 mm under skin surface
Dorsal	Cranially up to the thoraco-dorsal vessels, and more caudally up to an imaginary line between the anterior edge of the latissimus dorsi muscle and the intercostal muscles	Up to 5 mm dorsal of axillary vein or to costae and intercostal muscles	Up to 5 mm dorsal of subclavian vein or to costae and intercostal muscles	Pleura	Pleura	Minor pectoral muscle	Major pectoral muscle or costae and intercostal muscles where no muscle	Major pectoral muscle or costae and intercostal muscles where no muscle
Medial	Level 2, the interpectoral level and the thoracic wall	Medial edge of minor pectoral muscle	Junction of subclavian and internal jugular veins – >level 4	Including the jugular vein without margin; excluding the thyroid gland and the common carotid artery	5 mm from the internal mammary vein (artery in cranial part up to and including first intercostal space)	Medial edge of minor pectoral muscle	Lateral to the medial perforating mammarian vessels; maximally to the edge of the sternal bone	Guided by palpable/visible signs; if appropriate guided by the contralateral breast
Lateral	Cranially up to an imaginary line between the major pectoral and deltoid muscles, and further caudal up to a line between the major pectoral and latissimus dorsi muscles	Lateral edge of minor pectoral muscle	Medial side of the minor pectoral muscle	Includes the anterior scalene muscles and connects to the medial border of CTVn_L3	5 mm from the internal mammary vein (artery in cranial part up to and including first intercostal space)	Lateral edge of minor pectoral muscle	Lateral breast fold; anterior to the lateral thoracic artery	Guided by palpable/visible signs; if appropriate guided by the contralateral breast. Usually anterior to the mid-axillary line

ALND = axillary lymph node dissection.

12.7.1. Organs at risk

OAR 1-Ipsilateral and contralateral Lung

The full extent of the lungs to be contoured for accurate Dose Volume Histogram reporting.

OAR 2-Heart

The Heart should be outlined from the inferior aspect above the diaphragm, to the superior aspect below the pulmonary arch.

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OAR 3-Spinal Cord

The Spinal Cord should not normally be at risk but should be outlined if there is any concern that it will receive greater than 50% of the prescribed dose.

OAR 4-Contralateral Breast

The contralateral breast should be outlined if a non-tangential field arrangement is to be used for instance VMAT.

OAR 5 – Oesophagus

OAR 6 – Trachea

Brachial plexus is considered safe for the recommended fractionation. If a clinician is concerned about brachial plexus dose, then brachial plexus contouring is required for documentation and possible optimisation (e.g.: to avoid hot spots).
Field Simulation: Tangential fields should be placed to cover the PTV adequately while sparing the lung and heart as much as possible. Alternatively simulate fields as per PHY-POL-007 to align with the CT markers ensuring the amount of lung in the fields is minimised.

All target/OAR outlining and field simulation should be reviewed by the clinician.

Simple IMRT Tangents ± SCF

Target volumes	Target goals	
	Optimal	Mandatory
PTV_EVAL	V95% ≥ 95%	V95% ≥ 90%
		V100% ≥ 50%
	V107% ≤ 2%	Max Dose ≤ 110%
	Mean Dose 99.5%-100.5%	Mean Dose 99%-101%
SCF	D2cc ≤ 107%	
Plan Max Dose	Max Dose ≤ 110%	

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OARs	OAR Constraints	
	Optimal	Mandatory
Right Lung (left breast)		V2Gy < 1%
Right Lung (right breast)	V30% ≤ 15%	V30% ≤ 17%
		Mean dose ≤ 6Gy
Left Lung (left breast)	V30% ≤ 15%	V30% ≤ 17%
		Mean dose ≤ 6Gy
Left Lung right breast)		V2Gy < 1%
Heart (left breast only)	V25% ≤ 5%	
	V5% ≤ 30%	

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IMC, SIB, Hybrid and Partial Breast

		1. Whole Breast/ Partial Breast/ Chest Wall ± SCF ONLY (Field) (Based on Fast Forward + Import High)		2. Whole Breast/ Chest Wall + VMAT SIB ± SCF ONLY (Field) (Based on Import High + UK RCR consensus 2016)	
Organ	Target OAR	Objective	Constraint	Objective	Constraint
PTVTB DVH	Target	N/A	N/A	Median Dose 47.5-48.5Gy V45.6Gy>95%	V45.6Gy>90% V51.4Gy≤2% Max≤52.8Gy
PTVWB/CW	Target	V38Gy>95% V42.8Gy≤2%	V36Gy>90% D0.5cc≤44Gy	N/A	N/A
PTVWB/CW - PTVTB DVH	Target	N/A	N/A	V38Gy>95% Median Dose 39-41.2Gy V48Gy≤5%	V36Gy>90%
PTVWB- PTVTB DVH + 1cm	Target	N/A	N/A	V42.8≤5% V44Gy≤2cc	N/A
SCF Direct Field	Target	N/A	Direct Field D0.5cc≤44Gy	N/A	Direct Field D0.5cc≤44Gy
Body outside PTVs & SCF field	OAR	V42.8Gy≤2cc	Max≤44Gy	V42.8Gy≤ 2cc V44Gy≤0.5cc	N/A
Ipsi-lateral Lung □	OAR	N/A	V12Gy<15% (30% if SCF)	V18Gy<10% Mean<6Gy □	V18Gy<15% (30% if SCF)
Contra-lateral Lung	OAR	N/A	N/A	V2.5Gy<3% Mean<1Gy	V2.5Gy <15%
Heart (left sided tumour)	OAR	Mean<2Gy	V10Gy<5% V2Gy<30%	V13Gy<2% Mean<3Gy	V13Gy <10% Mean<4Gy
Heart (right sided tumour)	OAR	Mean<1Gy	V10Gy<5% V2Gy<30%	V5Gy<6% Mean<1.7Gy	V13Gy<10% Mean<4Gy
Contra-lateral breast	OAR	N/A	N/A	Mean<0.5Gy	Mean<1.5Gy

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		3.Breast/CW + Specified nodes SISO Tangents (incl. Wide) ± VMAT SIB (Based on Danish Guidelines +UK RCR consensus 2016 + Import High)		4.Breast/CW + Specified nodes Rotational IMRT Tomotherapy or VMAT ± SIB (Based on Danish Guidelines +UK RCR consensus 2016)	
Organ	Target OAR	Objective	Constraint	Objective	Constraint
PTVTB DVH	Target	Median Dose 47.5-48.5Gy V45.6Gy>95%	V45.6Gy>90% V51.4Gy≤2% Max≤52.8Gy	Median Dose 47.5-48.5Gy V45.6Gy>95%	V45.6Gy>90% V51.4Gy≤2% Max≤52.8Gy
PTVWB/CW(*)	Target	V38Gy>95% V42.8Gy≤2%	V36Gy>90% D0.5cc≤44Gy	V38Gy>95% V42.8Gy≤2%	V36Gy>90% D0.5cc≤44Gy
PTVWB (DVH) - PTV TB DVH	Target	V38Gy>95% Median Dose 39-41.2Gy V48Gy≤5%	V36Gy>90%	V38Gy>95% Median Dose 39-41.2Gy V48Gy≤5%	V36Gy>90%
PTVWB (DVH) - PTVTB DVH + 1cm	Target	V42.8≤5% V44Gy≤2cc	N/A	V42.8≤5% V44Gy≤2cc	N/A
Individual nodal volume PTV	Target	V36Gy>90% V42.8Gy≤2%	V32Gy>80% D0.5cc≤44Gy	V36Gy>90% V42.8Gy≤2%	V32Gy>80% D0.5cc≤44Gy
Body outside PTVs & fields	OAR	V42.8Gy≤ 2cc D0.5cc≤44Gy	N/A	V42.8Gy≤2cc D0.5cc≤44Gy	N/A
Ipsi-lateral Lung □	OAR	Mean<6Gy (if IMN Mean<13Gy)	V18Gy<30% (If IMN V17Gy<35%)	Mean<13Gy	V17Gy<35%
Contra-lateral Lung	OAR	V2.5Gy<3% Mean<1Gy	N/A	Mean<4Gy	N/A
Heart (left sided tumour)	OAR	V13Gy<2% Mean<3Gy	V13Gy <10% Mean<4Gy	Mean<4Gy	V17Gy<10% Mean<6Gy
Heart (right sided tumour)	OAR	V5Gy<6% Mean<1.7Gy	V13Gy<10% Mean<4Gy	Mean<4Gy	V17Gy<10% Mean<6Gy
Contra-lateral breast	OAR	Mean<0.5Gy (If IMN Mean<3.5Gy)	Mean<1.5Gy (If IMN N/A)	Mean<3.5Gy	N/A

12.8. Plan check

All plans are checked as per Patient Dosimetry and Treatment Planning (PHY-POL-007) in Pinnacle and MOSAIQ. Independent MU dose check is performed using RadCalc with MOSAIQ data transfer integrity verified using RadCalc Reconciler. A fluence delivery check is required if a complex IMRT/VMAT planning technique is employed.

All Plan checks reviewed by MPE for 26 Gy in 5 fraction protocol.

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12.9. Pre-treatment Verification

Treatment verification is to be undertaken day 1 prior to treatment.

12.10. Treatment IGRT

Image guidance is to be performed using daily CBCT & SGRT, see Elekta Image Guided Radiotherapy SOP (RT-SOP-414) or Varian Image Guided Radiotherapy SOP (RT-SOP-412).

12.11. Image Assessment

As per Varian Image Guided Radiotherapy SOP (RT-SOP-412) or Elekta Image Guided Radiotherapy SOP (RT-SOP-414), include all ipsilateral breast tissue in the clip-box and part of the sternum. 2 radiographers must review the images. Ensure the skin contour, chest-wall, heart and tumour bed clips match well. Review any shape change from the planning scan and highlight differences >1cm to planning who will notify the clinician if a re-plan/adaptive plan is required.

12.12. Treatment Delivery

As Per Radiotherapy Treatment Policy (RT-POL-014). SGRT delivered as per:

- Align RT Workflows Breast Chest Wall (RT-WI-249)
- Align RT Workflows Breast Chest Wall DIBH (RT-WI-250)
- Align RT Workflows Breast Chest Wall DIBH with bolus (RT-WI-294)
- Align RT Workflows Breast Chest Wall with bolus (RT-WI-295)

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14. Appendix

- Appendix 1: Prescriptions

Revision History

Version	Date Created	Created By	Description of change
1.0	April 2018	Clinical Leaders Forum	1 st version
2.1	March 2020	Breast Reference Group	Inclusion of PBI, revision to planning, treatment guidelines. Addition of 26Gy / 5# fraction Fast Forward
2.2	June 2020	Breast CRG	Boost with Fast Forward dose
3.0	August 2020	Breast CRG	Document reviewed and updated
3.1	November 2020	Breast CRG	Edit of inclusion criteria for breast boost and Appendix added with all prescriptions.
3.2	December 2020	Regional Imaging Services Lead (Lorinda Van Vollenhoven)	Removal of references to archived Diagnostics policies
3.3	January 2021	Mark Bowler, Head of Radiotherapy	Removal of section in DIBH section that states all FF breasts need to be treated with DIBH.
3.4	February 2021	Jo Summersell, Helen Roadway – Regional Principal Radiographers	Updated for use of DIBH for Rt breast

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Appendix 1 - Prescriptions

Radical

Breast and chest wall

40Gy / 15#

26Gy / 5#

Breast + SCF +/- IMC

40Gy / 15#

SIB Breast

48Gy / 15# - 48Gy to tumour bed and 40Gy to whole breast

Partial Breast

40Gy / 15#

26Gy / 5#

30Gy / 5# treated on alternate days

Breast Boost electrons

10Gy / 5#

13.35Gy / 5#

10.5Gy / 5#

16Gy / 8#

12Gy/4#

9Gy/3#

12.5Gy/5#

Breast Boost photons

10Gy / 5#

13.35Gy / 5#

16Gy / 8#

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Palliative

30-36Gy treated over 5-6#s with 1-2#'s per week (if treating lymph nodes max dose is 30 Gy in 5 or 6 fractions)

27Gy in 6 fractions, three times weekly over two weeks

28.5Gy in 5 fractions, weekly over five weeks.

Bone Mets

8Gy / 1#

20Gy / 5#

30Gy/10#.

Brain Mets

20Gy / 5#

30Gy / 10#