Pre-Treatment Workbook  
Clinical Radiotherapy Theory and Practice 2  
TRT-7-003  

PGDip Sep 2012 Cohort  

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Section A: Treatment planning reports

Breast plan

1. This patient was diagnosed with a T2N0M0 DCIS to the left breast with no nodal involvement, after a wide-local excision they are being treated with 3D conformal radiotherapy (3DCRT). A CT-sim data set with 3mm slice thickness is used for planning. The supine patient is scanned from 5cm superior to shoulders to 7cm below the inframammary fold, no contrast is used. The planning technique used is isocentric tangential fields covering breast tissue. The prescription is: Phase 1 - 40Gy in 15# and phase 2, a 10Gy in 5# electron boost to the Boost PTV.

2. The clinical target volume (CTV) is defined as the whole palpable breast tissue (Bentzen et al., 2008). This was defined at CT-sim with a trained radiographer palpating the breast (including a 1.5cm margin accounting for movement and penumbra) measured on the skin surface and marking the borders with radio-opaque markers (Barrett et al. 2009 pg.272). Hurkman et al. (2001) demonstrated that radio-opaque markers reduced inter-observer variation in delineation of breast tissue on CT-sim scans. 2 lateral and 1 medial reference marker are used to reduce rotation. Delineation of the tumour bed is recommended for all patients who have had breast conserving radiotherapy (Smith et al. (2010). The well-defined seroma (boost volume) is used for localisation here, however clips/seeds implanted at surgery would be recommended (Association of Breast Surgery, 2009). Surgical clips, 3D ultrasound, MRI, pre-operative CT scans and surgical notes can aid localisation.
5. The critical structures in this plan are the bladder, rectum and femoral heads that are located in close proximity to the prostate. This plan meets all dose constraints, displayed in table 1.

<table>
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<tr>
<th>Rectum</th>
<th>Bladder</th>
<th>Femoral heads</th>
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<tr>
<td>Tolerance doses</td>
<td>Achieved doses</td>
<td>Tolerance doses</td>
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<tr>
<td>V74 &lt; 3%</td>
<td>2%</td>
<td>V74 &lt; 5%</td>
</tr>
<tr>
<td>V70 &lt; 15-25%</td>
<td>17%</td>
<td>V60 &lt; 25%</td>
</tr>
<tr>
<td>V60 &lt; 50%</td>
<td>38%</td>
<td>V50 &lt; 50%</td>
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<tr>
<td>V50 &lt; 60%</td>
<td>47%</td>
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**Table 1**: OAR tolerance doses (Barrett et al., 2009 pg 49) and the doses achieved in this plan, taken from the DVH.

6. Studies show that a 3 field technique with direct laterals can spare rectal dose and a 6 field arrangement, can spare all OAR further (South et al., 2008). The use of IMRT and VMAT techniques have superseded 3DCRT in many departments due to the reduced OAR dose and increased conformity (Wu et al., 2004). South et al. (2008) demonstrated superior dose distributions have been seen using a forward planned IMRT techniques and the 2 dose levels can be treated simultaneously using IMRT. The organ motion of the rectum and bladder can be significant in prostate treatments, up to 3cm and so bladder filling and bowel emptying protocols are required (RCR, SCoR, IPEM, 2008). On-line volumetric image
• Field 4, SALO, is allocated to the wrong linac and has an incorrect field name.

• SALO enters on the contralateral side.

• Beam 3, Ant, enters directly through the lens.

• Beam 5, Post, only has 2 MU’s, which is too low to treat and exits through the right lens.

• The PTV is not covered by 95% -107% isodose (ICRU, 1993). Only 65% of the PTV is covered by 95% of prescription dose.

• The GTV is not covered with a uniform dose of 95-105%. (ICRU, 1993).

• Significant hot/cold spots present.

• Right lens exceeds tolerance dose.

• Beam arrangement is not optimal.

• PTV includes optic chiasm and optic nerves; no additional shielding has been used for this.

• The RLAT wedge is orientated incorrectly.

• Convolution algorithm is inappropriate.

To ensure this plan is suitable for treatment the set-up directions should be changed to be patient specific e.g. ANT/POST, errors have been attributed to incorrect interpretation of patient set-up details (RCR, SCoR, IPEM, 2008). A tilt board used to flex the head inferiorly as the PTV reaches into the temporal lobe will move the lens and orbits away from the anteriorly positioned fields. Field 4, SALO, should be allocated to Linac 4 and named SLLO (superior left lateral oblique), as there is no anterior aspect to this beam angle. Beam 5 (Post) should be removed, the MU’s are too low to treat and this is not a posteriorly positioned PTV. The LLAT beam should have
Volume modulated arc therapy (VMAT), is the next step in dynamic IMRT delivery, where a single or multiple radiation beams sweep in an uninterrupted arc around the patient, dramatically speeding up treatment delivery (Williams and Thwaites, 2000). The MLC’s move alike dynamic IMRT but by increasing the beam angles, the entry doses to healthy tissues are decreased and spread throughout the whole treatment area.

Verbekel et al. (2009) compared VMAT against conventional IMRT in HNC and found that OAR sparing was similar for both techniques yet a 2 arc VMAT technique gained better PTV dose homogeneity. Vanetti et al. (2009) also found when comparing the 2 modalities that a 2 arc VMAT technique gave superior target coverage with reduced healthy tissue dose. With small patient numbers and observations reserved to dosimetric parameters alone these studies are limited. However, both studies highlighted the significant reduction in monitor units (MU) required for VMAT and the overall reduction in treatment delivery time, which is of benefit to patients and departments.

Tomotherapy is also an arc technique in which the patient is treated slice by slice with VMAT in a manner similar to CT imaging and not a conventional linac. It can be thought of as a moving slip-ring gantry with a maximum width of 40 cm and adjustable slice thickness of up to 5cm (Khan, 2010). The 64-leaf round collimator modulates the fan shaped 6MV photon field during delivery (Khan, 2010). Servagi Vernet et al. (2014) compared tomotherapy to linac based VMAT for oropharyngeal cancer finding a small benefit in tomotherapy. Although this small study was restricted to dosimetric data, they concluded that rotational IMRT techniques present the maximum benefit in radiotherapy for HNC. This was supported by Wiezorek et al. (2011) who compared all
as on-line or ART. When OAR already reaches tolerance limits, imaging dose should be included during planning to allow contribution to be accounted for (stock et al. 2012). Lens sparing CBCT techniques can be used to minimise additional dose to the lens with frequently volumetric imaging in HNC.

**Conclusion**

IMRT requires greater time and resource commitment than 3DCRT, due to the necessity of more accurate delineations, optimization, treatment time and quality assurance (ICRU, 2010). IMRT can reduce healthy tissue dose and improve local control. Risks can be minimised with the use of IGRT, thus improving the therapeutic ratio in HNC radiotherapy. ART may become the new gold standard in HNC radiotherapy in the future, by accounting for the frequent anatomical changes that occur. However, IMRT and IGRT do increase integral dose, long-term results generated from RCT will increase the available data on this in the future. The evidence supporting IMRT in HNC cannot be ignored in emphasising the ethics of placing patients in control groups for further RCT in HNC IMRT. All patients should have access to techniques that can maximise their chances of local control and minimise normal tissue complication probabilities.
Section C – References


Appendix B

Prostate plan