NRG PROTOCOL RADIATION THERAPY TEMPLATE

DISEASE SITE: Prostate
SUB-COMPONENT: Photon/Proton Conventional, Hypo-fractionation & SBRT

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Maintained By: NRG Medical Physics Subcommittee
NRG Radiation Oncology Committee
In this section, the modality used to deliver radiation, the method for patient immobilization, and the method to correlate patient geometry and delivery geometry should be clearly described. Requirements for credentialing (including the phantom irradiation credentialing and the IGRT credentialing) should be explicitly specified in the protocol.

[STUDY CHAIRS: Refer to the NRG web site for RTQA Protocol Prescription Guidelines for writing RT prescriptions in NRG protocols [link to come].]

For SBRT protocols:
NOTE: A pre-treatment review is required for the first Arm ____ patient enrolled from each institution PRIOR TO DELIVERY of radiation treatment. The patient cannot start treatment until they have received approval from the Imaging and Radiation Oncology Core (IROC)-Philadelphia RT. The pre-treatment review process requires 3 business days from the receipt of complete data via the Transmission of Imaging and Data (TRIAD) system. If an unacceptable deviation occurs the next case may require a pre-treatment review. See Section _____ for specifics of submission requirements. After an institution has passed the pre-treatment review of the first Arm ____ patient enrolled, review of all other Arm ____ cases do not require pre-treatment review.

5.2 Radiation Therapy

Radiation Therapy Schema

Schema at the beginning of the protocol should be followed.

RANDOMIZATION:

In Arm 1 of the study, patients will receive ____ daily fractions of ____ cGy. These patients will be treated ____ days a week. The total dose will be ____ cGy. The total duration of treatment will be no shorter than ____ days and no longer than ____ days.
In Arm 2 of the study, patients will receive ____ fractions of radiation; each fraction size will be ____ cGy. The total dose will be ____ cGy. The ____ treatments will be scheduled to be delivered ____ over approximately ____ days. A minimum of ____ hours and a maximum of ____ hours should separate each treatment. The total duration of treatment will be no shorter than ____ days and no longer than ____ days.

5.2.1 Treatment Technology

List allowed Treatment Modalities (including energy): photons, protons, brachytherapy.
Required Capabilities: 3D Conformal Radiation Therapy (CRT), intensity modulated radiation therapy (IMRT), volumetric modulated arc therapy (VMAT), image guided radiation therapy (IGRT), etc.

Radiation therapy may be delivered in whole or in part using the following beam modalities and delivery techniques:

- Megavoltage photon beams, via 3D-CRT, IMRT, VMAT, Tomotherapy, MR-Linac, ViewRay Renaissance or MRIdian and Cyberknife.
- Proton beams, via either passive scattering or spot scanning (intensity modulated proton therapy - IMPT) techniques

For the 3D-CRT technique, coplanar or non-coplanar beam arrangements will be custom designed for each case, to deliver highly conformal dose distributions. For fixed gantry angle IMRT technique, a minimum of 5 gantry positions should be used. For the VMAT technique, a minimum of two arcs and a maximum of three arcs are recommended.

The recommended photon energies are 6-MV, 18 MV for 3D-CRT and 6-15 MV for IMRT/VMAT. For IMRT/VMAT, the use of beams ≥18 MV is discouraged. These energies will result in an increased neutron dose reaching the patient’s total body. If an institution uses mixed beam energies as part of the IMRT optimization process, using a limited number of beams with energy higher than 15 MV is allowed for the longer path lengths encountered in larger patients.

For protocols where Proton Therapy is allowed:
Radiation therapy will be delivered using proton beam therapy. A typical field arrangement using two opposed lateral fields is encouraged, but other field arrangements will be considered acceptable if approved by the protocol study investigators. Dose delivery by means of either passive double scattering or spot scanning pencil beam (IMPT) is acceptable. For passive double scattering beams, aperture, distal margin, proximal margin, smearing and smoothing will be determined for each case as per the standard clinical practice. Spot scanning treatments should be planned with consideration of plan robustness in the presence of intra-fraction prostate motion, effects of daily setup errors on radiological depths of target and on matched fields. Single field optimization (SFO), or single field uniform dose (SFUD) planning technique, for example, may be considered to improve plan robustness.

All patients shall undergo daily pre-treatment alignment using image guidance.
5.2.2 Immobilization and Simulation

Immobilization:

Proper immobilization is critical for this protocol. Patient setup reproducibility must be achieved using appropriate clinical devices.

During simulation imaging, depending upon the protocol, the patient may be positioned supine / prone as appropriate for patient comfort, sparing of organs at risk (OAR), or access to the target volumes:

- For supine positioning, the patient is placed supine on a regular head holder or pillow (depending on the patient comfort level). Use a vacuum cushion, custom mold, or similar immobilization device for immobilizing the patient’s legs. Depending on the protocol PI, the minimum immobilization allowed will be a pillow or wedge under the knees and the feet taped or rubber-banded together or equivalent. The patient’s arms must be placed across the chest and holding an immobilization aid or ring (so as to keep the arms out of the treatment region).
- For prone positioning, the patient is placed prone on a head holder. Use a vacuum cushion, custom mold, or similar immobilization device for immobilizing the patient’s feet. The patient’s arms must be outside the treatment beams and may be positioned superior to the patient. The legs should be slightly spread with the feet in internal rotation (depending on the patient comfort level) and a wedge used if necessary.

Novel immobilization devices may be used, provided that it conforms to the requirements of the protocol and is approved by the protocol study investigators. These immobilization devices must not interfere with image guidance.

For protocols where Proton Therapy is allowed:

In proton therapy, due to heavy charged particles there is no build-up effect on the patient skin due to the presence of the immobilization device. However, protons are highly sensitive to changes in radiologic depth, thus immobilization devices that intersect the treatment beam should be avoided or kept to a minimum. Finally, immobilization devices that intersect the treatment beam could influence the lateral dose gradient. Immobilization devices should therefore be radiologically and geometrically thin.

Motion Management Technique:

Please remove this subsection when motion management is not used.

Motion management is highly recommended for this protocol. In instances in which motion management is not required, larger expansion volumes will be used to adequately cover the motion-related uncertainties.

The types of motion management allowed on this study are a comfortably full bladder, etc. Consistent bladder filling procedures should be used for an individual patient for simulation and for each treatment i.e. the degree of bladder fullness at simulation should be made to duplicate what is anticipated for daily treatment. Caution the patient not to have a completely full bladder at simulation.
because the patient will not be able to maintain a completely full bladder for the entirety of the treatment.

A distended rectum can introduce a systematic patient positioning error that may increase the probably of missing the clinical target volume (CTV). Thus an enema before the simulation CT scan is strongly recommended. In addition, a hollow (robnel) catheter can be used at time of simulation to evacuate any existing flatus.

Rectal balloon with a predetermined standard fill volume to immobilize the rectum can be utilized, provided that it conforms to the requirements of the protocol and is approved by the protocol study investigators. If a rectal balloon is used, details regarding the balloon and filling shall be documented for each patient, for data analysis purposes.

The Space OAR Hydrogel (Augmenix Inc., Bedford, MA) spacer can be utilized provided that it conforms to the requirements of the protocol and is approved by the protocol study investigators. For these patients, a magnetic resonance imaging (MRI) scan shall be required to properly visualize the SpaceOAR Hydrogel and be fused to the simulation computed tomography (CT) scan. If SpaceOAR Hydrogel is used, details regarding use shall be documented for each patient, for data analysis purposes.

Target Localization for Simulation:

Please remove this subsection when target localization for simulation is not used.

Localization with bony anatomy or skin marks is not allowed. Localization with kV/MV 2D imaging using fiducial markers as well as 3D imaging such as cone beam CT (CBCT), CT rails and MRI is allowed. The utilization of fiducial markers (or transponders) permits superior verification of the prostate position relative to bony anatomy or skin marks and is strongly recommended in intact prostate radiation therapy protocols. The localization and alignment is based on the center of mass of the fiducial markers (or transponders). If fiducial markers are utilized, typically three or more fiducial markers are inserted into the prostate prior to the simulation. The type of fiducial markers that can be used is to be determined by the protocol investigators. An optimal fiducial marker is small, has minimal CT artifact and is easily visible on daily image guidance (fiducial makers that minimize proton beam attenuation are desired for proton therapy). Ideally, the fiducial markers must be inserted approximately 5 days prior to simulation, to allow for edema to subside and the fiducial position to stabilize. The time delay (if any) between insertion of the fiducials and simulation is to be determined by the protocol investigators. Fiducial markers with acceptable dose perturbation effects should be selected if proton therapy is allowed in the protocol.

5.2.3 Simulation Imaging

Please indicate “Not applicable” if it does not apply to your protocol. Please do not delete this subsection.

This subsection should include information about the extent of CT and MRI imaging, the resolution of
the scan information including the slice thickness, details on the allowed use of contrast agents, and the handling of tissue densities when contrast is used.

The treatment planning CT and/or MRI will be acquired with the patient setup in the same position as planned for daily treatments.

CT-based simulation imaging:

Depending upon the requirements and restrictions of the protocol, the primary volumetric imaging modality for target delineation and dose calculation purposes is CT. The field of view (FOV) and superior-inferior extent of the primary planning image shall be large enough so as to encompass the target volume, the entirety of the organs at risk (OARs), and any regions through which treatment beams may propagate through the patient, with sufficient margin to accurately account for lateral scatter in the treatment planning system. Ideally, the CT will consist of 3 mm thick (or less) axial slices, and will extend no less than from the top of the iliac crests cranially to the either 2 cm below the ischial tuberosity or the level of the lesser trochanter (whichever is more inferior) caudally. If 3 mm or less slice thickness is not possible for the entire scan, the reconstructed axial slice thickness shall, in the vicinity of the target volumes, be sufficient to enable accurate dose calculation resolution. The protocol recommends a reconstructed slice thickness of 3 mm (2 mm for SBRT) or less in this region. For regions of the patient either superior or inferior to the target-volume region, a greater slice thickness may be used (up-to 5 mm). Fiducial length may also mandate smaller slice thickness within the region encompassing the fiducial markers. Ideally, at least two slices should intersect each fiducial marker.

Use of contrast (IV, Oral, or rectal) is to be determined by the protocol investigators. Note, the placement of contrast in the rectum may cause the rectum to appear more anterior than it will be during treatment.

Artifacts in the Planning CT Images:

- **Image density artifacts due to hip prosthesis, gas or other artifacts:** When metal hip prosthesis are present, CT vendor available metal artifact reduction software can be utilized to improve image quality, but must be approved by the protocol study investigators. If low-density or high-density “streaks” or beam-hardening artifacts appear in the image within regions known to be of uniform density, density-override contours may be drawn to encompass these artifacts, with an appropriate density value forced within these contours.

MR-based simulation imaging:

Please remove this subsection when MRI simulation alone is not used.

Depending upon the requirements and restrictions of the protocol, the primary volumetric image acquired for target delineation and dose calculation purposes may be MR imaging, provided that the voxel-by-voxel density-assignment techniques are accommodated. The FOV and superior-inferior extent of the primary planning image shall be large enough so as to encompass the target volume, the entirety of the OARs, and any regions through which treatment beams may propagate through the patient.
The reconstructed axial slice thickness shall, in the vicinity of the target volumes, be sufficient to enable accurate dose calculation resolution. The protocol recommends a reconstructed slice thickness of 3 mm (2 mm for SBRT) or less in this region. If allowed by the protocol PI’s: For regions of the patient either superior or inferior to the target-volume region, a greater slice thickness may be used (up to 5 mm), with the scan range extending superiorly and inferiorly from the boundaries of the target volume.

For MRI simulation the following imaging protocol is recommended (depends on the protocol):

- Patient setup should represent treatment conditions (bowel prep, bladder prep, immobilization devices, etc.).
- Bladder filling should be comfortable to reduce image blurring.
- Buscopan or Glucagon shall be administered just prior to the scan to limit peristalsis unless contraindicated.
- No MR endorectal coil shall be used (because patient will not have a coil during treatment), although a surface body coil may be used.
- Field of view should generally be >14 cm, to include prostate and SV and skin surface.
- Each imaging sequence should strive to minimize acquisition times (< 5 minutes if possible) to minimize image blurring due to motion.
- Utilize optimal MR sequences for prostate such as T2W, T2W TSE/FSE, DWI, DCE, 3DFFE, T2 cube etc.
- A synthetic CT may be generated for treatment planning.

Imaging for Structure Definition, Image Registration/Fusion and Follow-up

Please remove this subsection if it does not apply to your protocol.

MRI may be used as part of staging and to assist in volume delineation in all eligible patients. MRI registration to CT shall be prostate-to-prostate registration. Bone-to-bone registration of the pelvis is not recommended. Appropriate image fusion techniques should be used for MRI-CT fusion. In the absence of fiducial markers, manual or automated registration restricted to prostate and periprostatic structures much be performed. In the presence of fiducial markers, a manual point based registration is recommended. The quality of registration must be evaluated prior to treatment planning. Internal peer review of registration quality is strongly recommended. Errors in registration translate to systematic errors through a course of treatment, and must be minimized.

5.2.4 Definition of Target Volumes and Margins

Note: All structures must be named for digital RT data submission as listed in the table below. The structures marked as “Required” in the table must be contoured and submitted with the treatment plan. Structures marked as “Required when applicable” must be contoured and submitted when applicable. Resubmission of data may be required if labeling of structures does not conform to the standard DICOM name listed. Capital letters, spacing and use of underscores must be applied exactly as indicated.

Entries in the first column of the list below will be entered and edited by the QA Staff. The PIs are required to specify the information in the second, third columns. The detailed specifications must
include crucial items such as boundary definitions and margins.

Delineation may be done either manually, or through an auto-segmentation process (using either image grayscale level differences or anatomic site-specific atlas), provided that all contours are verified manually.

The definition of target volume will be in accordance with ICRU Report 50: Prescribing, Recording, and Reporting Photon Beam Therapy as well as ICRU Report 62. Names must conform to AAPM TG 263 (Standardization Nomenclature in Radiation Oncology).

Gross Tumor Volume (GTV): GTV is defined as all known disease. The GTV for the purposes of this protocol is the prostate only.

Summary: GTV = Prostate

Clinical Target Volume (CTV): CTV is the GTV plus areas considered to contain microscopic disease, and is defined as the GTV prostate gland + 1cm of SV (Note: this can vary depending on the protocol).

Summary: CTV = Prostate + 1 cm proximal Seminal Vesicles

Planning Target Volume (PTV): The PTV will provide a margin around the CTV to compensate for the variability of treatment set up and internal organ motion. Careful consideration should be made to avoid undue expansion into either the rectum or bladder. Appropriate margin options are listed below.

Summary: PTV = CTV + 5 mm (mandated for SBRT protocols) up to 8 mm superiorly, inferiorly, anteriorly, and laterally, AND

PTV = CTV + 3 mm (mandated for SBRT protocols) up to 5 mm posteriorly.

Treatment will be given only to the PTV using fields shaped to exclude as much of the bladder and rectum as possible. Field arrangements will be determined during treatment planning to produce an optimal conformal plan in accordance with volume definitions. The treatment plan used for each patient will be based on an analysis of the volumetric dose distribution including dose-volume histogram (DVH) analyses of the PTV and critical normal structures.

For protocols where Proton Therapy is allowed:

In proton therapy, generic homogeneous PTV margins that exist in photon therapy are typically not sufficient. For photon beams, the PTV is primarily used to delineate lateral margins as referenced in each beams-eye-view. In the case of proton beams, in addition to these lateral margins, a margin in depth is also needed to allow for uncertainties in the knowledge of where the proton distal edges fall.

Evaluation Target Volume (ETV, for passive scattered plans): ETV will consist of the CTV plus an approximate 5-6 mm margin in all directions except in the posterior direction; where the margin will be 4-5 mm. Additional beam proximal and distal margins from ETC in beam directions will be
determined as per standard treatment planning process. The ETV can be used for plan normalization of both passive scattering and scanning beam proton treatment planning.

Scanning Target Volume (STV, for spot-scanning plans): STV is defined as a treatment planning aid when using scanning proton beams. The STV will typically consist of the CTV plus a variable margin as follows: 9-12 mm laterally, 5-6 mm anteriorly and superiorly-inferiorly, and 4-5 mm posteriorly. The STV can be used as an optimization objective for scanning beam, however, if robust optimization for range uncertainty and setup error is used, STV will effectively be the same as the ETV.

<table>
<thead>
<tr>
<th>Standard Name</th>
<th>Description</th>
<th>Delineation guidelines</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTV_XXXX</td>
<td>Gross Tumor Volume to receive XXXX cGy</td>
<td>Prostate alone</td>
<td>Required when applicable</td>
</tr>
<tr>
<td>CTV_XXXX</td>
<td>Clinical Target Volume to receive XXXX cGy</td>
<td>Prostate alone; prostate + proximal SV; Prostate – inferior border/apex defined using sagittal imaging (1 slice above GU diaphragm); Seminal vesicles (SV) 1 cm for proximal SV.</td>
<td>Required</td>
</tr>
<tr>
<td>PTV_XXXX</td>
<td>Planning Target Volume to receive XXXX cGy</td>
<td>5 to 8 mm in all directions except posteriorly, where a margin of 3 to 5 mm is used</td>
<td>Required</td>
</tr>
</tbody>
</table>

*XXXX is the prescribed dose in cGy.

5.2.5 Definition of Critical Structures and Margins

Note: All structures must be named for digital RT data submission as listed in the table below. The structures marked as “Required” in the table must be contoured and submitted with the treatment plan. Structures marked as “Required when applicable” must be contoured and submitted when applicable. Resubmission of data may be required if labeling of structures does not conform to the standard DICOM name listed. Capital letters, spacing and use of underscores must be applied.
Entries in the first column of the list below will be entered and edited by the QA Staff. The PIs are required to specify the information in the second, third columns. The detailed specifications have to include crucial items such as boundary definitions and margins.

<table>
<thead>
<tr>
<th>Standard Name</th>
<th>Description</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectum</td>
<td>Rectum</td>
<td>Required</td>
</tr>
<tr>
<td>Bladder</td>
<td>Bladder</td>
<td>Required</td>
</tr>
<tr>
<td>Femur_head_L</td>
<td>Left Femoral Head</td>
<td>Required</td>
</tr>
<tr>
<td>Femur_head_R</td>
<td>Right Femoral Head</td>
<td>Required</td>
</tr>
<tr>
<td>Femur_heads</td>
<td>Both Femoral Heads</td>
<td>Required</td>
</tr>
<tr>
<td>Colon_sigmoid</td>
<td>Sigmoid</td>
<td>Required when applicable</td>
</tr>
<tr>
<td>Bowel_small</td>
<td>Small Bowel</td>
<td>Required when applicable</td>
</tr>
</tbody>
</table>
Penile Bulb | Required when applicable  
---|---  
Urethra | Required when applicable  
External | Required when applicable  
Body | Required when applicable  

**Detailed Specifications**

- Bladder, rectum, sigmoid, small bowel, femoral heads, urethra, penile bulb will be considered as solid organs rather than just contouring the walls for each organ.
- The bladder should be contoured from its base to the dome.
- The rectum should be contoured from the anus (at the level of ischial tuberosities) for a length of 11-15 cm or to the recto sigmoid flexure. This generally is below the bottom of the sacroiliac joints. Care should be taken to avoid sigmoid or small bowel.
- Each femoral head should be considered separately. Each femoral head should be outlined down to the interface between the greater and less trochanters.
- The tissue within the skin and outside all other critical normal structures and PTV (i.e. Body) is to be designated as unspecified tissue.

**5.2.6 Dose Prescription**

Note: The information provided in this section can be used for adjusting the dose constraints for treatment planning purposes. This table together with the planning priority table should be used during dose optimization. It is important to remember that ideal plans might not be achievable in all cases. Thus, the Compliance Criteria table could be different than the information given here. Cases will be scored using the Compliance Criteria table.

Prescription dose to the PTV shall be according to the following: In Arm 1 of the study, patients will receive ____ daily fractions of ____ cGy. These patients will be treated ____ days a week. The total dose will be ____ cGy. The total duration of treatment will be no shorter than ____ days and no longer than ____ days. In Arm 2 of the study, patients will receive ____ fractions of radiation; each fraction size will be ____ cGy. The total dose will be ____ cGy. The ____ treatments will be scheduled to be delivered ____ over approximately ____ days. A minimum of ____ hours and a maximum of ____ hours should separate each treatment. The total duration of treatment will be no shorter than ____ days and no longer than ____ days.

Note: The fractionation dose values provided in the following tables are just for the generic template and protocol PI’s will need to determine these values for individual protocols.
1) Standard fractionation (78 Gy in 39 fractions to prostate):

<table>
<thead>
<tr>
<th>Target Standard Name</th>
<th>Dose (Gy)</th>
<th>Fraction Size (Gy)</th>
<th># of fractions</th>
<th>Frequency</th>
<th>Dose specification technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_7800</td>
<td>78</td>
<td>2</td>
<td>39</td>
<td>Daily</td>
<td>Covering 98% of PTV</td>
</tr>
</tbody>
</table>

2) Hypofractionation (70 Gy in 28 fractions to prostate):

<table>
<thead>
<tr>
<th>Target Standard Name</th>
<th>Dose (Gy)</th>
<th>Fraction Size (Gy)</th>
<th># of fractions</th>
<th>Frequency</th>
<th>Dose specification technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_7000</td>
<td>70</td>
<td>2.5</td>
<td>28</td>
<td>Daily</td>
<td>Covering 98% of PTV</td>
</tr>
</tbody>
</table>

3) SBRT (36.25 Gy in 5 fractions to prostate):

<table>
<thead>
<tr>
<th>Target Standard Name</th>
<th>Dose (Gy)</th>
<th>Fraction Size (Gy)</th>
<th># of fractions</th>
<th>Frequency</th>
<th>Dose specification technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_3625</td>
<td>36.25</td>
<td>7.25</td>
<td>5</td>
<td>Copy information from prescription section</td>
<td>Covering 98% of PTV</td>
</tr>
</tbody>
</table>

The maximum dose must not be within an “Organ at Risk” such as the Rectum, Bladder, Penile Bulb, etc.

5.2.7 Compliance criteria

The compliance criteria listed here will be used to score each case. Given the limitations inherent in the treatment planning process, the numbers given in this section can be different than the prescription table. The Per Protocol and Variation Acceptable categories are both considered to be acceptable. The Per Protocol cases can be viewed as ideal plans, and the Variation Acceptable category can include more challenging plans that do not fall at or near the ideal results. A final category, called Deviation Unacceptable, results when cases do not meet the requirements for either Per Protocol or Variation Acceptable. Plans falling in this category are considered to be suboptimal and additional treatment planning optimization is recommended.

\[ V_{xGy} [cc], V_{xGy} [%], V_{x}[cc], V_{x}[%]: \text{Volume [cc or \%] receiving Dose [Gy, or \%]} \]
\[ CV_{xGy}[cc], CV_{xGy} [%], CV_{x}[cc], CV_{x} [%]: \text{Complement Volume [cc or \%] receiving Dose [Gy, or \%]} \]
\[ D_{xcc}[Gy], D_{xcc} [%], D_{x}[Gy], D_{x} [%]: \text{Dose [Gy or \%] to Volume [cc or \% of total volume]} \]
\[ DC_{xcc}[Gy], DC_{xcc} [%], DC_{x}[Gy], DC_{x} [%]: \text{Dose [Gy or \%] to Complement Volume [cc or \% of total volume]} \]
\[ \text{Minimum dose is defined to } D_{99\%}[Gy] \text{ or } D_{99\%}[\%] \]
Maximum dose is defined as $D_{0.03cc}^{Gy}$ or $D_{0.03cc}^{\%}$
Mean$^{Gy}$ or Mean$^{\%}$: Mean dose in Gy or \%
$R_{100}$: Ratio of 100\% isodose volume over structure volume [SBRT only]
$R_{50}$: Ratio of 50\% isodose volume over structure volume [SBRT only]

Target Volume Constraints and Compliance Criteria

Target Volume Constraints:

Normalization of Dose: For both arms, the isodose line used for the prescription dose shall cover a minimum of ____\% of the PTV.

Note: The dose volume constraint values provided in the following tables are just for the generic template and protocol PI’s will need to determine these values for individual protocols.

**Conventional:**

<table>
<thead>
<tr>
<th>Name of Structure</th>
<th>Dosimetric parameter*</th>
<th>Per Protocol</th>
<th>Variation Acceptable</th>
<th>Deviation Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_7800</td>
<td>V100%[%]</td>
<td>$\geq 98$</td>
<td>$\geq 95$</td>
<td>$&lt; 95$</td>
</tr>
<tr>
<td></td>
<td>D99%[%]</td>
<td>$\geq 95$</td>
<td>$\geq 93$</td>
<td>$&lt; 93$</td>
</tr>
<tr>
<td></td>
<td>D0.03cc[%]</td>
<td>$\leq 107$</td>
<td>$\leq 110$</td>
<td>$&gt; 110$</td>
</tr>
</tbody>
</table>

**Hypofractionation:**

<table>
<thead>
<tr>
<th>Name of Structure</th>
<th>Dosimetric parameter*</th>
<th>Per Protocol (Gy)</th>
<th>Variation Acceptable (Gy)</th>
<th>Deviation Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_7000</td>
<td>D0.03cc[Gy]V100%[%]</td>
<td>$\geq 98$</td>
<td>$\geq 95$</td>
<td>$&lt; 95$</td>
</tr>
<tr>
<td></td>
<td>D99%[%]</td>
<td>$\geq 95$</td>
<td>$\geq 93$</td>
<td>$&lt; 93$</td>
</tr>
<tr>
<td></td>
<td>D0.03cc[%]</td>
<td>$\leq 107$</td>
<td>$&lt; 110$</td>
<td>$&gt; 110$</td>
</tr>
</tbody>
</table>

**SBRT:**
<table>
<thead>
<tr>
<th>Name of Structure</th>
<th>Dosimetric parameter*</th>
<th>Per Protocol (Gy)</th>
<th>Variation Acceptable (Gy)</th>
<th>Deviation Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_3625</td>
<td>V100%[%]</td>
<td>≥98</td>
<td>≥95</td>
<td>&lt;95</td>
</tr>
<tr>
<td></td>
<td>D99% [%]</td>
<td>≥95</td>
<td>≥93</td>
<td>&lt;93</td>
</tr>
<tr>
<td></td>
<td>D0.03cc [%]</td>
<td>≤115</td>
<td>≤120</td>
<td>&gt;120</td>
</tr>
</tbody>
</table>

**Normal Structure Constraints and Compliance Criteria**

Constraints should be based on references, with the references provided, or an explanation of the origin of the constraint should be given.

**Conventional:**

<table>
<thead>
<tr>
<th>Name of Structure</th>
<th>Dosimetric parameter*</th>
<th>Per Protocol</th>
<th>Variation Acceptable</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectum</td>
<td>V70Gy[%]</td>
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**Hypofractionation:**

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<th>Variation Acceptable</th>
<th>Notes</th>
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**SBRT:**

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For patients where the maximum point dose (to a point that is 0.03 cc) exceeds XX Gy, visualization of the urethra is required.

*Per Protocol range is excluded from Variation Acceptable range.

**In these table, each dose value represents a treatment planning guideline and not a clinical study constraint.

5.2.8 Treatment Planning Priorities and Instructions

- List treatment planning recommendations and give link to FAQs

- Critical Structure and Target priorities must be listed in order of decreasing importance.

The following list is given as an example:

1. PTV
2. Rectum
3. Bladder
4. Femur_Head_R and Femur_Head_L
5. PenileBulb
6. Urethra

Required algorithms
(Convolution/Superposition, Monte Carlo, etc…)

Acceptable choices of algorithm are listed at:
http://rpc.mdanderson.org/rpc/Services/Anthropomorphic_20Phantoms/TPS20-
%20algorithm%20list%20updated.pdf. Any algorithm used for this study must be credentialed by IROC Houston.

Primary dataset for dose calculation
The primary dataset for dose calculation must ideally be a CT. In the case in which contrast is present during the treatment planning CT, the density of the contrast should be overridden to a representative background electron density or relative stopping power/mass density.

If an MRI is used for treatment planning, appropriate and approved density conversion techniques shall be utilized. The TPS may assign electron densities or physical densities for each voxel in the volumetric planning image, to account for tissue density for beam attenuation and dose calculation. Depending upon the protocol, the following techniques may be used for density assignment:

- Voxel-by-voxel assignment using an appropriate image value to density table (IVDT)
- Uniform assignment of the entire patient volume, to the density of water or the density of tissue
- Assignment of specific ROIs to specific uniform density values appropriate to the ROI; examples include density overrides to correct for image artifacts (e.g. due to the presence of highly-attenuating materials), to remove from the image any contrast agent that was present during simulation, and the assignment of ROIs delineated in an MR planning image to an appropriate density (“synthetic CT”)

An accurate accounting of the variable tissue density within the planning image shall be done within the TPS. For CT-based planning, a CT-number-to-electron-density, CT-number-to-physical density, CT-number to relative stopping power, or CT-number-to-mass-density table shall be measured within the institution’s imaging system, and reviewed and credentialed as appropriate. For MR-based planning, an atlas-based “synthetic CT” image with appropriate densities assigned to all regions of interest may be obtained from the planning MR image.

-Dose matrix resolution
Dose grid size should be ≤ 3 mm in all directions.

5.2.9 Patient specific QA
- Describe technique and give Gamma pass rate recommendation

For IMRT/VMAT/IMPT delivery, although an automated MU verification calculation may be permitted subject to protocol credentialing and approval, a direct measurement of the dose distribution from the designated treatment system shall be performed prior to delivery of the first fraction. All components of the inverse-plan verification technique, including the planning system, treatment machine, and detector hardware and analysis procedure, shall be credentialed according to guidelines established by IROC-Houston for protocols utilizing inverse planning.
For IMRT/VMAT/IMPT delivery, patient specific QA is highly recommended. Any patient-specific QA performed should follow your institutional guidelines. The recommended minimum patient specific QA criterion is for 90% of the comparison points to pass a $\pm 3\%/3\text{mm}$ Gamma Index analysis.

For protocols where Proton Therapy is allowed:
For passive scattered or uniform scanned beam plans that utilize a patch field, patient specific QA must be performed with the compensator.

For IMPT plan QA, measurement in multiple depths is required.

5.2.10 Daily Treatment Localization/IGRT

Image-guided radiation therapy (IGRT) is radiation therapy using imaging to facilitate accuracy and precision throughout its entire process from target and normal tissue delineation, to radiation delivery, to adaptation of therapy considering anatomic and biological changes over time. In this section we use the terminology IGRT to focus on image-guidance at the time of radiation delivery.

Acceptable IGRT techniques will be utilized for initial localization, tracking and periodic monitoring of isocenter location and beam positioning throughout treatment. The localization technique will be documented for each institution on the facility questionnaire. If an institution uses more than one treatment/localization technology, each must be described and appropriately credentialed.

The following information should be provided for localization guidance:

- Is IGRT tied to margin reduction?
- What are the allowed image guidance methods? 2D x-ray, 3D-xray, electromagnetic localization, optical surface imaging, 3D CBCT, 3D CT Rails, 3D MRI, other
- What are the image alignment priorities: fiducial markers, bony anatomy, prostate, rectum, etc.
- How frequent should the localization checks be provided? Typically daily checks are recommended.
- What are the conditions for applying corrections and re-imaging? (e.g. reimage if shifts are greater than 5mm, and only apply corrections if they are greater than 1 mm)
- When is during treatment imaging mandated?

Prior to treatment delivery, the positioning of the patient may be refined using any of the listed verification imaging techniques. Patient position refinement may either be translational only (along the three cardinal directions: lateral, longitudinal, or vertical), or it may include rotational corrections (pitch, roll, and yaw). The basis of the IGRT alignment shall be determined prior to the first fraction delivery and documented in the patient’s electronic medical record. Criteria for internal review of the repositioning shall be established by the institution and subject to review and credentialing by the protocol. If required by the protocol, verification imaging following the patient repositioning shall be acquired, the frequency of which shall be determined by the protocol.

Recommended daily, pre-treatment IGRT techniques:

The x-ray IGRT systems that can be used are:
2D and 3D IGRT systems are allowed for this protocol:
- These systems can use either kV or MV x-rays
- A computerized method for image registration is required for determination of the patient shift information
- The image registration can be either manual (drag and drop images) or automatic

Examples of 2D systems are the ExacTrac, on board imaging (OBI), electronic portal imaging device (EPID), CyberKnife real-time system, etc.

Examples of 3D systems are helical Tomotherapy CT imaging, cone-beam CT and CT-in-the-room, MR-Linac, Renaissance and MRIdian systems, etc.

Note that MV EPID imaging is allowed as long as the above conditions are met and the appropriate anatomy/landmarks are clearly visible.

The use of target tracking during treatment is encouraged when this technology is available and strongly encouraged when the treatment time from initial beam-on to the end of dose delivery is longer than _____ (e.g. 8 ) minutes.

Repeat IGRT procedures can be used to detect and correct field positions when real-time tracking is not available. Treatments that take less than _____ (e.g. 8 ) minutes do not require a mid-treatment IGRT procedure.

Source to surface distance (SSD) measurement via optical distance indicator should be performed prior to fraction delivery once every five fractions and compared to treatment plan reference SSD’s. If a verification image is acquired during the same session, the SSD measurement shall be done following patient repositioning and imaging, but prior to the fraction delivery.

Management of Radiation Dose to the Patient from IGRT

NRG Oncology is concerned about the estimated doses given from IGRT, and is committed to limiting the imaging dose when IGRT is used in any of its protocols. This can be accomplished by avoiding the use of this technology to make small changes in patient positioning that are within the stated PTV margins. The imaging dose to the patient may become significant if repeated studies are done for patients with severe set up problems (e.g. requiring frequent corrections that are larger than the PTV margins). It is recommended that patients demonstrating severe set up problems during the first week of treatment be moved to a treatment with larger margins.

If possible, verification imaging dose shall be calculated or estimated within the TPS. An action level for excess dose due to unplanned verification imaging, as well as the measures to take if the action level is reached or exceeded, shall be established by the institution and subject to approval by the protocol.

5.2.11 Case Review

The Principal Investigators, XXX, MD will perform ongoing remote RT Quality Assurance Review after cases enrolled have been received at IROC Philadelphia-RT.