Please complete the WGTP Plan Quality Survey
https://redcap.link/WGTPSurvey
Enhancing a Physicist’s Role in the Assessment of Treatment Plan Quality

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and
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Disclosures

• This presentation does not represent the opinions of AAPM or any working group.

• I have changed employment from UCSD to Varian Medical Systems.
Learning Objectives

• To define quality in radiotherapy treatment planning
• To understand the role of a physicist in determining quality
• To learn how to evaluate technical features that impact plan quality
• To learn how to evaluate clinical features that impact plan quality
• To understand how automation and data-driven plan quality control tools can be used clinically to support quality
Learning Objectives

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Definition of quality

Quality (Merriam Webster):

“How good or bad something is.”

Plan quality (TG-308):

“Given a desired therapeutic dose of radiation to a patient, treatment plan quality is the degree to which a dose distribution maximizes tumor control and minimizes normal tissue injury for a given technique.”
Stoplight approach to plan quality

**Unacceptable:** Plan is unsafe for treatment

**Acceptable:** Plan will not harm patient, but could be improved

**High Quality:** Plan strikes a balance between target coverage, normal tissue sparing, robustness, and clinical practicality
Spectrum of Plan Quality

Unacceptable

Acceptable

High Quality
Often the majority of plans are **acceptable** and the goal as a physicist is to ensure/transition to **high quality**.
Learning Objectives

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Role of a Physicist in Radiation Oncology

“The first responsibility of the radiation oncology physicist is to the patient--to assure the best possible treatment given the state of technology and the skills of the other members of the radiation oncology department.” – Task Group 001, Report 38
Create a culture that promotes quality

- Multi-disciplinary approach
- Review plan quality critically
- Use automated/data-driven methods
Potential hurdles to a culture that promotes quality

Potential Hurdles:
- Environment does not support physics feedback
- Remote work/new hires
- Resource constraints
- Physicist unsure if quality is adequate

Solutions:
- Relationship building and added value
- Implement clear processes and procedures
- Emphasize ILS for systematic improvement
- Increase planning exposure for physicists
Technical and Clinical Aspects

**Technical Aspects**
- Beam Configuration
  - Number of Arcs/Beam
  - Arc/Beam Angle Selection
  - Collimator/Jaw Selection
- Optimization Objectives
- Plan Modulation
- Treatment Devices
- Density Overrides

**Clinical Aspects**
- Images
- Registrations
- Contours
- Isodose
- DVHs
- Plan Sum Evaluation

According to RO-ILS data, “Treatment” is the most common step for discovery of issues.
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Technical Aspects: Beam Configuration

Technical Aspects

- Beam Configuration
  - Number of Arcs/Beam
    - Arc/Beam Angle Selection
    - Collimator/Jaw Selection
  - Optimization Objectives
  - Plan Modulation
  - Treatment Devices
  - Density Overrides

Number of Arcs/Beams

- Too few:
  - Reduced degrees of freedom necessary for maximum OAR sparing/target coverage
- Too many:
  - Decreased delivery efficiency, slow dose rate (arcs)
  - Standardized based on institution, treatment site, complexity
Technical Aspects: Number of Beams/Arcs

Background:
  • Prostate + Nodes with SIB

Issue Identified:
  • Original plan utilized 4 full arcs
    o Collimator: 10, 45, 315, 90
    o Fraction MU: 724
    o Mean Dose Rate: 113 MU / minute

Improvement:
  • Replanned using 2 full arcs
    o Collimator: 10, 90 degrees
    o Fraction MU: 590
    o Mean Dose Rate: 260 MU / minute
  • Consistent plan quality with more efficient delivery
**Technical Aspects: Beam Configuration**

**Technical Aspects**
- **Beam Configuration**
  - Number of Arcs/Beam
- **Arc/Beam Angle Selection**
  - Collimator/Jaw Selection
  - Optimization Objectives
  - Plan Modulation
  - Treatment Devices
  - Density Overrides

**Arc/Beam Angle Selection**
- Avoid entrance through poorly immobilized anatomy
- Clearance of patient
  - Both for field path AND between fields/arc
  - Minimize shifting of patient
- Maximize target coverage from multiple angles
- Minimize entry through critical OARs
Technical Aspects: Beam/Arc Angle Selection

Background:
- Patient simulated without shoulder immobilization for head-and-neck cancer
- VMAT arcs had to include shoulders

Issue Identified:
- Shoulder setup uncertainty decreases plan robustness

Improvement:
- Shoulder avoidance structure included in the optimization
- Plan quality remained the same
- Plan robustness improved
Technical Aspects: Beam/Arc Angle Selection

Background:
- 3D T/L Spine prescribed 600 cGy x 3 fractions
- Physician specifically requests “AP/PA” plan

Issue Identified:
- Plan violates institutional 3-fx bowel constraints

Improvement:
- Discussed AP/PA rationale with physician
  - Physician wanted something quick for the patient, hence AP/PA request.
- Suggested / executed replan with single conformal arc
  - Negligible impact to on-table time for patient
- Bowel D2cc reduced by 35% (1880 cGy → 1240 cGy)
- Bowel mean dose reduced by 43% (700 cGy → 400 cGy)
### Technical Aspects: Beam Configuration

#### Technical Aspects
- **Beam Configuration**
  - Number of Arcs/Beam
  - Arc/Beam Angle Selection
- **Collimator/Jaw Selection**
  - Optimization Objectives
  - Plan Modulation
  - Treatment Devices
  - Density Overrides

#### Collimator/Jaw Selection
- **Collimator Angle:**
  - Utilize collimator angles to minimize in-field OARs
  - Varying collimator angles for multiple arcs to increase degrees of freedom
- **Jaw Selection for Large Targets**
  - Maximize critical OARs with low dose objectives under the jaws
  - Limited jaw size and MLC travel
Technical Aspects: Collimator/Jaw Selection

Background:
- Long Scalp and left upper neck/face treatment
- Treatment on Varian HDMLC linac

Issue Identified:
- Field too wide resulting in open MLC shapes due to carriage limitations

Improvement:
- Selected better collimator angles and jaw limitations to reduce MLC travel
- Reduces unnecessary dose to patient
# Technical Aspects: Optimization Objectives

<table>
<thead>
<tr>
<th>Technical Aspects</th>
<th>Optimization Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Beam Configuration</td>
<td>• Achievable Objectives</td>
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<tr>
<td>• Number of Arcs/Beam</td>
<td>• Reasonable separation between min and max goals for targets</td>
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<tr>
<td>• Arc/Beam Angle Selection</td>
<td>• Appropriate sparing of OARs</td>
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<tr>
<td>• Collimator/Jaw Selection</td>
<td>• Conflicting Objectives</td>
</tr>
<tr>
<td>• <strong>Optimization Objectives</strong></td>
<td>• OAR/Target objectives not simultaneously achievable</td>
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<tr>
<td>• Plan Modulation</td>
<td>• Omitted OARs/Targets</td>
</tr>
<tr>
<td>• Treatment Devices</td>
<td>• Objective weights should follow OAR/Target prioritization</td>
</tr>
<tr>
<td>• Density Overrides</td>
<td></td>
</tr>
</tbody>
</table>
Technical Aspects: Optimization Objectives

Background:
• Complex prostate + nodes SIB case with multiple dose levels
• Single ring structure used to promote conformality

Issue:
• Dose objective selected for ring structure was ineffective for certain PTV dose levels
• Results in poor plan conformity and risk of fracture to vertebral body
Technical Aspects: Optimization Objectives

Background:
- Complex prostate + nodes SIB case with multiple dose levels
- Single ring structure used to promote conformality

Issue:
- Dose objective selected for ring structure was ineffective for certain PTV dose levels
- Results in poor plan conformity and risk of fracture to vertebral body

Improvement:
- Create separate ring structures and apply appropriate objectives to increase conformity
Technical Aspects: Missing Objectives

**Background:**
- Oropharynx treatment with 3 prescription dose levels.
- Larynx dose violated the clinical goal but the physician accepted as it was not a top priority. (PTV coverage was prioritized.)

**Issue:**
- Larynx ROI was not included in the optimization objectives.

**Improvement:**
- Larynx objective was added in the optimization.
- Larynx dose decreased without compromising PTV coverage and cord dose.
  - PTV 54 Gy, PTV
  - Larynx average dose 44 Gy -> 36 Gy.
Technical Aspects: Plan Modulation

**Technical Aspects**
- Beam Configuration
- Number of Arcs/Beam
- Arc/Beam Angle Selection
- Collimator/Jaw Selection
- Optimization Objectives

**Plan Modulation**
- Heavily modulated plans may exceed accuracy of dose calculation models
  - Resulting QA rates may decrease
  - Best to evaluate/mitigate prior to plan review/approval
- Plan complexity evaluation includes:
  - MU ratios within expected range
  - MLC aperture size/motion in BEV
  - Complexity factors when available
Definition of modulation factor: MU/fractional dose

Typical modulation factors:

3D: ~1 (without wedge)
FIF: 1-1.5
VMAT: 2-5
SMLC IMRT: 3-7
DMLC IMRT: 5-10
Multi-Met SRS: 3-8 (see figure)

*Figure Courtesy of Richard Popple, PhD
Technical Aspects: Plan Modulation

Background:
- QA failures identified for VMAT plans

Issue:
- Modulation factor (MF) vs QA error indicates higher incidence of failure with MF > 4

Improvement:
- Plans with MF>4 require physics review prior to MD approval
- Utilize TPS tools to reduce plan modulation and open up segments

*Figure Courtesy of Yang Kyun Park, Ph.D.*
Technical Aspects: Modulation and Delivery Efficiency

Background:

- 2400 cGy / 1 Fx SRS Brain

Issue:

- Planner pushed unconstrained VMAT optimization to an MU factor of 3.6
  - 95% PTV coverage, CI = 1.02, GI = 3.65

Improvement:

- Replanned with strict MU objective + high-strength aperture shape controller → MU factor 2.6
  - 95% PTV coverage, CI = 1.02, GI = 3.70
- Reduction of about 2400 MU or nearly 2 minutes of beam-on time at nominal 1400 MU/min dose rate with no decrease in plan quality
Technical Aspects: Treatment Devices

### Technical Aspects
- Beam Configuration
- Number of Arcs/Beam
- Arc/Beam Angle Selection
- Collimator/Jaw Selection
- Optimization Objectives
- Plan Modulation
- **Treatment Devices**
- Density Overrides

### Treatment Devices
- Couch model
- Immobilization devices
- Motion management devices (e.g., diaphragm control device)
Technical Aspects: Treatment Devices Inclusion

Background:
- Plan created without couch but treated with couch

Issue:
- Omission of couch impacts PTV coverage

Improvement:
- Inclusion of treatment couch in plan
- More accurate representation of dose to patient (TG 176 for more details)
Technical Aspects: Density Overrides

- Beam Configuration
- Number of Arcs/Beam
- Arc/Beam Angle Selection
- Collimator/Jaw Selection
- Optimization Objectives
- Plan Modulation
- Treatment Devices

Density Overrides

- Volumes with density that are not physically present during treatment
- Location, volume, proximity to target all dictate when it is important
- Contrast, hardware, artifacts
- No universal standard
Technical Aspects: Density override

Background:
- Patient had hip replacement hardware.

Issue:
- No density was overridden because the materials were unknown.

Improvement:
- According to TG 63, most prosthetic devices are made of steel (8.1 g/cm$^3$), Co-Cr-Mo (7.9g/cm$^3$), or titanium (4.3g/cm$^3$) and the comparison was provided to physicians to make informed clinical decision.
Learning Objectives

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Clinical Aspects: Images

Clinical Aspects

- Images
- Registrations
- Contours
- Isodose
- DVHs
- Plan Sum Evaluation

Images

- Proper motion management /immobilization
- Correct planning images
- Quality of the planning images
  - Resolution, contrast
  - Field-of-view, scan length
  - Fiducial location
  - Artifacts
Clinical Aspects: Missing Tissue

- FOV
  - Recon at extended FOV
    - Check HU
  - Extend external and override to tissue/fat
  - Block entrance through affected areas

- Scan-length
  - Extend for dose calculation full scatter conditions
  - Make sure parallel organs are fully contoured
Clinical Aspects: Missing Tissue

Background:
- HN treatment with shoulders cut off at level of nodal volumes

Issue:
- Patient was too large for CT FOV
- Missing tissue will cause uncertainty in dose calculation

Two options for improvement:
- Create a contour and restrict beam entrance through areas where the CT is cut off
  - Entrance avoidance in the optimization for that particular structure
  - Arc angle avoidance for the entire plan
- Reconstruct the CT with an extended FOV and verify HU is adequate for dose calculations
Clinical Aspects: Insufficient CT scan length

Background:
- Liver SBRT treatment

Issue:
- Scanning parameter was entered incorrectly by mistake and a limited CT dataset was acquired.
- PTV is located at the edge of the CT images acquired

Improvement:
- Re-simulation if part of an important parallel organ or PTV is missing in the CT scan
- Extend CT to add missing tissues for dose calculation in full scatter condition
Clinical Aspects: Motion Artifact in Images

Background:
• Liver SBRT with fiducials implanted for a gated treatment

Issue:
• Poor 4DCT acquisition from simulation resulting in artifacts in reconstructed Avg 30-70 phase scan

Improvement:
• Resimulation to ensure motion can be adequately managed.
Clinical Aspects: Registrations

Clinical Aspects:
- Images
- **Registrations**
- Contours
- Isodose
- DVHs
- Plan Sum Evaluation

Registrations:
- Evaluate primary to secondary dataset registrations
  - Rigid and deformable registrations
  - Positioning of patient in secondary dataset may be different
  - Accuracy of registration may be limited to small region
- Communicate any unusual variations to physician.
Clinical Aspects: Registrations

**Background:**
- Brain SRS case contoured using fused MR

**Issue:**
- MR fusion not accurate
- Results in inaccurate target contours

**Improvement:**
- Review image registration and target contours prior to planning/approval

AAPM TG-132 recommends that clinics establish a patient-specific QA practice for efficient evaluation of image registrations.
### Clinical Aspects: Contours

**Clinical Aspects**
- Images
- Registrations
- **Contours**
- Isodose
- DVHs
- Plan Sum Evaluation

**Contours**
- Accuracy of contours impacts plan trade-offs and quality evaluation
  - Missing contours
  - Missing interpolation
  - Stray pixels
  - Incomplete contours
  - Incorrect labeling of contours

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**Flowchart:**
- Patient Simulation
- Plan Creation/Plan Quality Review
- Physician Review
- Physics Pretreatment Check
- Treatment
## Clinical Aspects: Contours

### Table 1.A.1: Photon/electron EBRT high-risk failure modes for initial plan/chart review. Failure modes (FMs) with RPN>100 are listed in order of decreasing RPN. For each FM the number of checks is listed, i.e. the number of different checks from Table 1.C i which might identify this failure mode.

<table>
<thead>
<tr>
<th>FM#</th>
<th>Process Step</th>
<th>Failure Mode</th>
<th>Cause</th>
<th># of checks</th>
<th>RPN</th>
<th>S</th>
<th>O</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tx Plan</td>
<td>“Wrong” or inaccurate MD contours</td>
<td>Workflow/Communication Issue, e.g., Attending MD does not review resident contours, MD does not clearly identify dose levels, Incorrect CT dataset, Fusion incorrect or with wrong image set, Target motion not considered, Wrong set of contours imported</td>
<td>7</td>
<td>261.3</td>
<td>7.4</td>
<td>4.9</td>
<td>7.2</td>
</tr>
<tr>
<td>2</td>
<td>Pt Assmt</td>
<td>Miscommunication about prior dose, pacemaker, pregnancy</td>
<td>Information not communicated or available information incorrect</td>
<td>4</td>
<td>214.1</td>
<td>7.4</td>
<td>5.5</td>
<td>5.3</td>
</tr>
<tr>
<td>3</td>
<td>Tx Plan</td>
<td>Improper margins for PTV</td>
<td>Structural issues, e.g. policies and procedures inadequate or non-existent, margins not provided</td>
<td>2</td>
<td>198.0</td>
<td>5.5</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>4</td>
<td>Tx Plan</td>
<td>Unintentional re-irradiation of a previously treated area</td>
<td>Technical Issue: Inadequate medical records in hospital data base, Re-creation of prior plan incorrect, Missing previous RT dose structure, No records available (foreign country, distant past, lost)</td>
<td>3</td>
<td>181.2</td>
<td>7.7</td>
<td>3.8</td>
<td>6.2</td>
</tr>
<tr>
<td>5</td>
<td>Pt Assmt</td>
<td>Incorrect or missing pathology</td>
<td>Pathology report incorrect or not read by MD</td>
<td>3</td>
<td>180.3</td>
<td>6.8</td>
<td>3.6</td>
<td>7.3</td>
</tr>
<tr>
<td>6</td>
<td>Tx Plan</td>
<td>Dose in plan does not match intended</td>
<td>Wrong Rx provided to planner, e.g. why MD wrote wrong Rx (typo, e.g. 220x30 vs. 200x33) maybe via email, MD unintentionally writes Rx to max dose, wrong Rx signed off in chart or Rx not signed</td>
<td>7</td>
<td>175.3</td>
<td>6.4</td>
<td>5.8</td>
<td>4.8</td>
</tr>
<tr>
<td>7</td>
<td>Tx Plan</td>
<td>“Wrong” or inaccurate dosimetrist contours</td>
<td>Human performance issue by dosimetrist or other, e.g. distraction or interruption, inattention, slip, lack of training, mistakes CTV for PTV, forgets to expand CTV to PTV, full structure not contoured (e.g. partial cord in Tx region)</td>
<td>5</td>
<td>175.2</td>
<td>6.2</td>
<td>5.5</td>
<td>5.2</td>
</tr>
<tr>
<td>8</td>
<td>Pt Assmt</td>
<td>Sub-optimal treatment plan or approach related to communication or coordination with multidisciplinary care</td>
<td>Lack of coordination or miscommunication with e.g. surgeons, med onc, etc.</td>
<td>4</td>
<td>160.2</td>
<td>4.9</td>
<td>4.3</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Strategies for effective physics plan and chart review in radiation therapy: Report of AAPM Task Group 275
Clinical Aspects: Incomplete Contours

**Background:**
- Prostate + nodal SIB plan with dose leaking to the posterior side

**Issue:**
- Rectum was not completely contoured in the superior border

**Improvement:**
- Completed the rectum contour to fix the dose leak
## Clinical Aspects: Isodose

### Clinical Aspects

- Images
- Registrations
- Contours
- **Isodose**
- DVHs
- Plan Sum Evaluation

### Isodose

- Review low, medium, high dose levels, including dose gradients
- Understand the ‘typical’ dose gradient different modalities/sites of treatments
- Understand the preference of trade-offs in your institution
Clinical Aspects: Isodose

3 dose levels HN plan
1. Hot Spots in PTV?
2. RX dose coverage → Cause of dose spillage?
3. Dose conformality
4. Dose gradient
Clinical Aspects: Isodose/Dose Gradient

Background:
- 2400 cGy / 1 Fx SRS Brain
- Physician and planner both *inexperienced* with SRS
- Physician instructs planner to create a “*uniform dose*”
- Dosimetrist complied:
  - Max Dose = 106%, CI = 1.03, Brain V12Gy = 9cc

Issue Identified:
- GI > 10!

Improvement:
- Replanned with
  - Max Dose = 133%, CI = 1.02, V12 = 2.5cc
  - GI = 4.5
- *Education* provided to staff on interplay between dose gradient and dose heterogeneity and why a “uniform” dose was not desirable for an intact brain met

MPPG 9.a recommends that clinics organize on-site review and proctoring of their first clinical SRS/SBRT procedure, conferring with professionals with experience relevant to the new service
Clinical Aspects: DVHs

Clinical Aspects
- Images
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DVHs
- Understand national and institutional normal tissues goals
  - Prioritized from MD written directive on a per-patient basis
- Reflect appropriate prioritization of planning goals in optimization
  - OAR constraints > target coverage > OAR goals
Example of Prioritization of Objectives

- Sample Written Directive for conventional lung radiotherapy
  - **Priority 1: OAR Constraints**
    - Take precedence **over target coverage**
    - Generally driven by well-established organ tolerances
  - **Priority 2: Target Coverage**
  - **Priority 3: OAR Goals**
    - Designed to push for better plan quality
    - Do not sacrifice target coverage to meet these goals
Clinical Aspects: Objective Priorities

- **Background**
  - MD specified brachial plexus and submandibular gland sparing are *OAR constraints*

- **Issue**
  - PTV *under-covered* in initial plan
  - All OARs optimized with *equal* priority (50)

- **Improvement**
  - Increase priorities for brachial plexus and submandibular gland to reflect the order requested by MD
  - Achieved *BOTH* the PTV coverage and OAR constraints
Clinical Aspects: Plan Sum Evaluation

- **Images**
- **Registrations**
- **Contours**
- **Isodose**
- **DVHs**
- **Plan Sum Evaluation**

**Plan Sum Evaluation**

- Use EQD2 when comparing different delivered fractionation scheme
  - Retreatment cases
  - Mixed modalities
- Consider appropriate registration for important aspects of the evaluation (may require multiple)
- University of Michigan has formalized the process
  - Special Medical Physics Consultation – Previous Treatment Evaluation
  - Resource: https://www.advancesradonc.org/cms/10.1016/j.adro.2019.05.007/attachment/511ab5a9-b32c-4075-b6ba-e75be68cbd74/mmc2.pdf
Clinical Aspects: Plan Sum Evaluation

Background:
- Previously treated to T-spine with \textbf{400 cGy x 5 fx} = 2000 cGy.
- New plan to the LT Lung for \textbf{267 cGy x 15 fx} = 4005 cGy overlaps with T-spine plan.
- Physician wants to ensure that OAR tolerances are not exceeded.

Issue Identified:
- Using absolute doses can \textbf{severely underestimate} both target and OAR doses when fractional doses are larger than 2 Gy.

Improvement:
- Dose distributions from both plans were converted to equivalent dose in 2 Gy per fraction (EQD2) prior to summation.
Learning Objectives

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• To understand the role of a physicist in determining quality
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• To learn how to evaluate clinical features that impact plan quality

• *To understand how automation and data-driven plan quality control tools can be used clinically to support quality*
Why automate a process?

- Standardization
- Equivalent or higher quality
- Does something not previously practical
- Patient safety
- Higher efficiency
Quantifying plan quality

• Population-based scoring methods
  • QUANTEC/Clinical trials for specific treatment sites
  • TG-101/HyTEC for SBRT

• Patient-specific (data-driven) scoring methods
  • Predicts dose value that depends on the unique features of each patient
Patient-specific scoring methods

• First principle (FP) technique
  • Calculates the **dose gradients** around the target volume based on individual patient anatomy and dosimetry

• Knowledge-based DVH prediction
  • Calculates **achievable DVH metric** based on patient anatomy and past planning experience

• Deep learning 3D dose prediction
  • Calculates **optimal 3D dose distribution** based on patient anatomy and past planning experience
Population-based scoring

<table>
<thead>
<tr>
<th>Priority</th>
<th>Structure Template</th>
<th>Structure Plan</th>
<th>Type</th>
<th>Prescription</th>
<th>Constraint</th>
<th>Goal</th>
<th>PrstSBRT_VMAT</th>
<th>Pass/Fail</th>
<th>Verify OK</th>
<th>Comment</th>
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<tbody>
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<td>PTV_3625</td>
<td>PTV_3625</td>
<td>Target</td>
<td>Prostate: 3625cGy</td>
<td>V100% ≥ (Soft)</td>
<td>95-94%</td>
<td>95%</td>
<td>✔️</td>
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<tr>
<td>1</td>
<td>PTV_3625</td>
<td>PTV_3625</td>
<td>Target</td>
<td>Prostate: 3625cGy</td>
<td>V98% ≥ (Soft)</td>
<td>98%</td>
<td>98,173%</td>
<td>✔️</td>
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<td>Max ≤</td>
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<td>3918.3cGy</td>
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<td>PTV_3625</td>
<td>Target</td>
<td>Hot Spot Within</td>
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<td>✔️</td>
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<td>Rectum</td>
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<td>Max</td>
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<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>2</td>
<td>Rectum</td>
<td>Rectum</td>
<td>OAR</td>
<td>D0.05c ≤</td>
<td>4000cGy</td>
<td>3755.9cGy</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

Rectum did not meet the institutional guideline ➔ ACCEPTABLE PLAN
Patient-specific scoring

With the patient anatomy, the rectum dose in the plan is HIGH QUALITY.
Clinical implementation of data-driven quality control and automated treatment planning

AAPM Task Group No. 308 [https://www.aapm.org/org/structure/?committee_code=TG308](https://www.aapm.org/org/structure/?committee_code=TG308)

<table>
<thead>
<tr>
<th>Building a Model</th>
<th>Model Validation</th>
<th>Clinical Use of Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Case selection</td>
<td>• Independent from the patient used for model training</td>
<td>• Develop guideline for clinical use</td>
</tr>
<tr>
<td>• Data curation and labeling</td>
<td>• Represent the range of patient geometries, plan geometries, and plan prescriptions for which the model will be clinically used</td>
<td>• Range of clinical cases</td>
</tr>
<tr>
<td>• Model training</td>
<td>• Run the model prediction and evaluate the quality of plans generated</td>
<td>• Standardization protocol</td>
</tr>
<tr>
<td>• Model Evaluation</td>
<td></td>
<td>• Contour</td>
</tr>
</tbody>
</table>

Utilizing model trained in other institutions

• ORBIT-RT
• Understanding the case characteristics
  • Contour
  • Dose/fx
  • Training set plan quality

• Contour
• Beam arrangement
• Plan evaluation metrics
### Utilizing Automation for Plan Quality Check

#### Examples of Scriptable Checks

- Automating review of technical and clinical aspects upstream can improve plan quality
- Planners run checker before physics plan quality review

<table>
<thead>
<tr>
<th>Technical Aspects</th>
<th>Auto check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Configuration</td>
<td></td>
</tr>
<tr>
<td>Number of Arcs/Beam</td>
<td></td>
</tr>
<tr>
<td>Arc/Beam Angle Selection</td>
<td></td>
</tr>
<tr>
<td>Collimator/Jaw Selection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check # arc/fields</td>
</tr>
<tr>
<td></td>
<td>Check clearance</td>
</tr>
<tr>
<td></td>
<td>No zero collimator angle, Jaw-tracking turned on</td>
</tr>
<tr>
<td>Optimization Objective Priorities</td>
<td>Not trivial</td>
</tr>
<tr>
<td>Plan Modulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check Total MU/FX dose</td>
</tr>
<tr>
<td>Treatment Devices</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check correct couch is inserted</td>
</tr>
<tr>
<td>Density Overrides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check bolus &amp; metal override</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clinical Aspects</th>
<th>Auto check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Images</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check sim date/scan protocol</td>
</tr>
<tr>
<td>Registrations</td>
<td>Not trivial</td>
</tr>
<tr>
<td>Contours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check missing critical OARs, interpolation, stray pixel</td>
</tr>
<tr>
<td>Isodose</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check hot spot outside targets</td>
</tr>
<tr>
<td>DVHs, Dose Gradients, Plan Sum Evaluation</td>
<td>Score card, data-driven tool</td>
</tr>
</tbody>
</table>
Example of Checker for Planners to Run Before MD Review

- Checks 27 high priority technical & clinical aspects that can lead to replan
- EzPreCheck: Catching planning deficiency in early planning phase

*Slide Courtesy of Mu-Han Lin, Ph.D. and Yang Kyun Park, Ph.D.*
Example of Comprehensive Checker
Resources for Automatic Checkers

- Commercial products
  - API script-based and standalone checkers
- Institution developed checkers

- Scripting workshops hosted by vendor
- Online resources
  - GitHub
  - Webinars
Conclusion

• Physics review of technical and clinical aspects that impact plan quality upstream can improve plan quality

• Physicists are encouraged to increase exposure to planning and exercise planning skills to aid plan quality checks

• Automation can improve the plan quality and efficiency
Acknowledgments

• Lindsey Olsen, PhD
• Sean L. Berry, PhD
• Joey P. Cheung, PhD
• Dustin J. Jacqmin, PhD
• James A. Kavanaugh, PhD
• Minsun Kim, PhD
• Mu-Han Lin, PhD
• Eric Lobb, MS
• Jose C. Pichardo, PhD
• Sua Yoo, PhD
Please complete the WGTP Plan Quality Survey

https://redcap.link/WGTPSurvey