Head and Neck Planning with Pinnacle at Moffitt Cancer Center

Dawn Gintz, CMD, RTT
Dosimetry Coordinator of Research and Education
Head and Neck / Cutaneous Service, Radiation Oncology
Head and Neck Planning

- Simulation
- Contours
  - Targets
  - Normal structures
- Planning with Pinnacle
  - Contouring
  - Creating beams
  - Optimizing
  - More optimizing
- Evaluating the plan
Simulation

• Aquaplast mask
  – Attention to bridge of nose and concha of ears
  – Bite block for tonsil
  – Head extension / no bite block for BoT
  – Add bolus under the mask if needed
• CT scan with and without contrast
  – 2-3 mm cuts
• PET fusion
  – PET ideally in treatment planning position
Immobilization

Tonsil with a bite block & bolus
Contours

• Physician contouring
  – GTV
  – CTV
  – PTV
• Normal Tissue Contours
Physician Contouring

• GTV (primary and nodal gross disease)
  – Use contrast enhanced CT
  – Integrate PET or MRI in treatment planning position
  – Integrate physical exam (photos are helpful) & laryngoscopy (videos or photos are helpful)

• CTV
  – 5 mm expansion

• PTV (high dose targets)
  – 2.5 – 3 mm expansion with daily IGRT
  – Limited within 5 mm of the patient external contour
Physician Contouring cont.

- CTV (low dose target / elective neck)
- PTV (low dose target)
  - 2.5 – 3 mm expansion
  - Limited within 5mm of the patient external contour
Physician Contouring / GTV
Physician Contouring / CTV
Physician Contouring / PTV
Physician Contouring / CTV Elective Neck
Normal Tissue / Organs

Nomenclature – Adopted the NRG naming protocol as our standard

• SpinalCord, SpinalCord_05
• BrainStem, BrainStem_03
• Cerebellum
• Parotid_R
• Parotid_L
• Parotid_R_Stem
• Parotid_L_Stem
• Submandibula_R
• Submandibula_L

• OralCavity
• Larynx
• Thyroid
• SPC (superior pharyngeal constrictor)
• MPC (middle pharyngeal constrictor)
• IPC (inferior pharyngeal constrictor)
• Mandible
• Esophagus
Ready for Dosimetry

- Contours
- Rx
- Source document
- Imaging report
- Pathology
- Dose objective worksheet
Setup Tab

- Outside-patient air threshold
- Verify isocenter position
- Couch removal
Big Picture

• Planning strategy:
  – Is it a Seq or a SIB plan?
  – Re-irradiation?
  – How long are the targets? Tomo?
  – Are there artifacts that need to be corrected?
  – Is there a pacemaker?
  – Maybe a shoulder replacement?
Artifacts / Density Distortions

- Correct the artifacts by creating a contour that encompasses the craziness.
- Edit out the bone, teeth, air, etc that should not have the density overridden.
- Force a density override
- Verify using the Density Override Display page

![Diagram showing a contour and density settings](image)
Contours

• Targets:
  – The elective neck PTVs should not overlap the high dose PTVs
  – Easier to optimize

• Avoid the exterior of the patient by 5mm
Conformality / Avoidance Structures

- Used to create dose falloff
- Create a 1mm margin around all of the targets: PTVs, CTVs, GTVs
  - Note:
    - PTVs are brought in 5 mm from the external
    - CTVs and GTVs are not
Creating the Conformality Structures

CTV outside of the PTV

Don’t constrict with the avoidance rings - 1 mm goes around the CTV
High Dose Conformality Ring

• A 7-9 mm ring is created around the high dose PTV
  – staying inside of the external contour
  – outside of the 1 mm buffer

• It only goes around the high dose PTV – not the low dose PTV
High Dose Conformality Ring
High Dose Conformality Ring cont.

- low dose PTV
- high dose PTV
- 1 mm buffer
- 7-9 mm high dose ring
Low Dose Conformality Ring

- Add a 6 mm ring around the low dose PTV and the high dose ring.
Rings and Avoidance Structure

- Add three consecutive 1 cm rings around the previous rings
- Create an avoidance structure in the posterior neck – behind the cord and the brainstem
Clean Contours

- Remove errant contours
- Be careful with the larynx, mandible, etc

<table>
<thead>
<tr>
<th>ROI: cleaning contours</th>
<th>Minimum Contour Area: 0.1 cm(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overlap Threshold: 88 %</td>
</tr>
</tbody>
</table>

Problems Encountered During Scan:

32 curves have area less than cutoff of 0.100

<table>
<thead>
<tr>
<th>Rescan</th>
<th>Delete Curves</th>
<th>Move Curves to New ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dismiss</th>
<th>Help</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Points

- Verify the isocenter
- Only one point to choose from?
Points

- Verify the isocenter
- Only one point to choose from?
- Located in a good place?
  - Move it to take advantage of the smaller leaves
Points

- Verify the isocenter
- Only one point to choose from?
- Located in a good place?
  - Move it to take advantage of the smaller leaves
  - Sort points
Beams

2 arcs (sometimes 3, rarely 4)
  – Always 6x
  – Dynamic Arc
356 degree opposing arcs
  – 178 to 182, 182 to 178
Collimator rotated 15 degrees
  – Limit the overlap of interleaf leakage
  – 3 arcs: collimator of 15, 345, 30
Dose and Evaluation

- 0.3 cm dose grid
- Prescribe
  - dose per fraction
  - 100%
  - ROI Min
  - GTV
Inverse Planning / Parameters

- Convolution dose iteration 15
- Apply tumor overlap fraction
- Compute intermediate dose

do not use the overlap function for tumors that overlap with critical structures (structures that take planning priority)
Inverse Planning

• Optimization process
  – Go slow, be methodical
  – Is a good plan achievable without the constraints?
  – Uniform dose vs. minimum dose and maximum dose
Inverse Planning

- Easy to achieve
- PTV_high_dose
  - Uniform dose
    - Bump Rx dose up slightly
    - Not always helpful
  - Max dose
    - About 3% higher or 2 Gy
  - Min dose
- PTV_low_dose
  - Max dose
  - Min dose
  - Max DVH
  - Shape the dose heterogeneity
Inverse Planning
Critical Structures

• Critical structures only
• Is an ok plan achievable?
  – Easier to look for issues
Inverse Planning
Dose Falloff

Ring structures:

- High dose conformity ring
  - Max dose of the high dose Rx
  - Slight Max EUD

- Low dose conformity ring
  - Max dose is the low dose Rx
  - Weight of 0.5
  - Slight Max EUD
Inverse Planning

Dose Falloff

Ring structures:

- Each ring gets a slightly lower max dose and a max EUD
- The avoid structure in the posterior neck is limited with a max dose of 35 Gy and a max EUD of 15 Gy
Inverse Planning
Dose Falloff

• Ring structures have an easy dose gradient
Inverse Planning Optimizing

• The first optimization round falls apart
  – Warm start and re-run
• After you have a good initial plan
  – Always a warm start
  – Add dose constraints for the normal tissue structures
    • Be a cheater!
    • Use max DVHs
  – Tighten the rings / falloff structures
• Extra optimization structures
  – Create avoidance structures to push dose
  – Create planning normal tissue contours
• Treat the PTV
  – Don’t allow cold carved out areas
  – Be creative at the target/normal tissue interface to avoid hotspots
Inverse Planning
Initial Optimization

• Does the DVH make sense?
• Isodose curves
  – Somewhat conformal
  – PTVs covered
• First optimization round falls apart – just run optimizer again
Inverse Planning
Normal Tissue Contours

- Add dose constraints for the normal tissue structures to the optimizer
  - Be a cheater! for the Max EUD
Inverse Planning
Rings and Falloff Structures

• Continue tightening the rings
  – Go slow
  – Use the objective value and the gEUD as a guide
Inverse Planning
Max DVH Objectives

Max DVH objectives along with Max EUD objectives
- More control
- Faster results

Dose Volume Histogram
Inverse Planning
Using Extra Planning Structures

Avoidance structures to push dose
• Adds emphasis to avoid normal tissues
• Break-up bridging dose
• Decrease dose spill
Inverse Planning Using Extra Structures

Create “planning” normal tissue contours

- Use the normal tissue contour as the base - subtract out a few of the inner rings = an avoidance structure that can be pushed without creating hotspots at the target / normal tissue interface
  - Max Dose
  - Max EUD
  - Max DVH objectives
Evaluating the Plan

- Sequential Boost / Simultaneous Integrated Boost Plans
  - vagaries
- Is it safe?
  - Cord
  - Brainstem
- Dose to the targets / tabular DVH
  - GTV
  - PTV_high_dose
  - PTV_low_dose
- Normal tissue dose / DVH
- Isodose curves
  - 95% isodose lines (high dose and elective neck)
  - 100% and 105% isodose lines
  - 50% isodose line
Evaluating the Plan Targets

• GTV
  – $V(D_{Rx}) \geq 100\%$

• PTV\_high\_dose
  – $D_{max} \leq 105\%$
    • Preferably in the GTV
    • Not on the mucosa
    • Not in the larynx or constrictors
  – $D_{min} \geq 95\%$
  – $V(D_{Rx}) \geq 95\%$

• PTV\_low\_dose
  – Limit the $D_{max}$ / hetergeniety
  – $D_{min} \geq 95\%$
  – $V(D_{Rx}) \geq 95\%$

• GTVs
  – The GTV should be covered by the 100% of the Rx Dose

• PTV\_high\_dose
  – The dose to the PTV\_high\_dose should be less than 105% of the Rx and greater than 95% of the Rx.
  – At least 95% of the PTV\_high\_dose should be covered by the Rx dose.

• PTV\_low\_dose
  – The dose to the PTV\_low\_dose should be greater than 95% of the Rx and minimize as much as possible the volume greater than 105% of the Rx.
  – At least 95% of the PTV\_low\_dose should be covered by the Rx dose.
## Evaluating the Plan Targets

<table>
<thead>
<tr>
<th></th>
<th>Max cGy</th>
<th>Min cGy</th>
<th>$V(D_{RX})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV_7000</td>
<td>7350</td>
<td>6650</td>
<td>$\geq 95%$ of the PTV is covered by the 7000 cGy line</td>
</tr>
<tr>
<td>GTV_7000</td>
<td>7350</td>
<td>7000</td>
<td></td>
</tr>
<tr>
<td>PTV_5600</td>
<td>Minimize volume that receives 5880</td>
<td>5320</td>
<td>$\geq 95%$ of the PTV is covered by the 5600 cGy line</td>
</tr>
</tbody>
</table>
Evaluating the Plan using Tabular DVH
GTVp & GTVn

<table>
<thead>
<tr>
<th>Dose (cGy)</th>
<th>0.0</th>
<th>6600.0</th>
<th>13200.0</th>
<th>19800.0</th>
<th>26400.0</th>
<th>33000.0</th>
<th>39600.0</th>
<th>46200.0</th>
<th>52800.0</th>
<th>59400.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.53</td>
<td>0.53</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We want 100%

<table>
<thead>
<tr>
<th>Dose (cGy)</th>
<th>0.0</th>
<th>6600.0</th>
<th>13200.0</th>
<th>19800.0</th>
<th>26400.0</th>
<th>33000.0</th>
<th>39600.0</th>
<th>46200.0</th>
<th>52800.0</th>
<th>59400.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>8.99</td>
<td>8.99</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We want 100%
Evaluating the Plan using Tabular DVH

PTV_High_Dose

- 6600 cGy (Rx)
- 6270 cGy (95% Rx)

We want ≥ 95%
We want 100%
Evaluating the Plan using Tabular DVH Max Dose

The location of the max dose is evaluated with the isodose lines as well:
- Should be in the GTV
- Should not on the mucosa or in the pharyngeal axis

Max Dose: 6930 cGy (105% Rx)

We want < 105%
Evaluating the Plan using Tabular DVH

**PTV_low_dose**

<table>
<thead>
<tr>
<th>Dose (cGy)</th>
<th>Include in plan report: Yes</th>
<th>Bin Size:</th>
<th>Number of Bins:</th>
<th>Columns:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>260.63</td>
<td></td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4140.0</td>
<td></td>
<td>4140.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*We want ≥ 95%*

**PTV low dose**

<table>
<thead>
<tr>
<th>Dose (cGy)</th>
<th>Include in plan report: Yes</th>
<th>Bin Size:</th>
<th>Number of Bins:</th>
<th>Columns:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>260.63</td>
<td></td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>3933.0</td>
<td></td>
<td>3933.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*We want 100%*
## Normal Tissue / Organs

<table>
<thead>
<tr>
<th>Organ at Risk</th>
<th>$D_{\text{max}}$ (cGy)</th>
<th>Dose-Volume Limit</th>
</tr>
</thead>
</table>
| SpinalCord_05       | Myelopathy $V(5000 \text{ cGy}) < 0.03 \text{ cc}$ | $V(3000 \text{ cGy}) < 45\%$  
$V(4000 \text{ cGy}) < 10\%$  
Lhermitte’s $< 2600$ |
| Brainstem_03        | Neuropathy $V(5400 \text{ cGy}) < 0.03 \text{ cc}$ | Or $D(2.7 \text{ cc}) < 5500 \text{ cGy}$  
$D(0.9 \text{ cc}) < 6000 \text{ cGy}$  
Nausea $< 3600 \text{ cGy}$ |
<table>
<thead>
<tr>
<th>Organ at Risk</th>
<th>Dose-Volume Limit</th>
<th>Organ at Risk</th>
<th>Dose-Volume Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PartialBrain</td>
<td>V(5000 cGy) ALARA</td>
<td>Larynx</td>
<td>V(3500 cGy) &lt; 79%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V(4500 cGy) &lt; 45%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V(5500 cGy) &lt; 32%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V(6500 cGy) &lt; 22%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aspiration &lt; 4100 cGy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PEG Dependence &lt; 5100 cGy</td>
</tr>
<tr>
<td>Parotid_R</td>
<td>Mean &lt; 2600 cGy</td>
<td>Thyroid</td>
<td>10–15cc Gland – mean &lt; 1000 cGy</td>
</tr>
<tr>
<td>Parotid_L</td>
<td></td>
<td></td>
<td>20 cc Gland – mean &lt; 2500 cGy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25 cc Gland – mean &lt; 4000 cGy</td>
</tr>
<tr>
<td>Parotid_Stem_R</td>
<td></td>
<td>SPC/MPC/IPC</td>
<td>Aspiration &lt; 5400 cGy</td>
</tr>
<tr>
<td>Parotid_Stem_L</td>
<td></td>
<td></td>
<td>Stricture &lt; 5400 cGy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PEG Dependence &lt; 5100 cGy</td>
</tr>
<tr>
<td>Submandibula_R</td>
<td>Mean &lt; 3900 cGy</td>
<td>IPC</td>
<td>V(4000 cGy) &lt; 65%</td>
</tr>
<tr>
<td>Submandibula_L</td>
<td></td>
<td></td>
<td>V(5000 cGy) &lt; 47%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V(6000 cGy) &lt; 11%</td>
</tr>
<tr>
<td>OralCavity</td>
<td>Mean &lt; 3200 cGy</td>
<td>Mandible</td>
<td>V(7000 cGy) &lt; 6.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V(6000 cGy) &lt; 35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>V(5000 cGy) &lt; 62%</td>
</tr>
</tbody>
</table>
Sequential Boost Isodose Dose Spill
Dose Spill

Composite plan can look a little loose

Perspective:
- 4140 cGy
- 5600 cGy
Patient #1
R BoT/Neck / T1 N1 M0
Patient #1
R BoT/Neck / T1 N1 M0

GTVp_6600 100%
GTVn_6600 100%
PTV_6600 98.9%
PTV_4140 99.6%

Max dose 6814 cGy
103%

All constraints met except R SMG
Patient #1
R BoT/Neck / T1 N1 M0

All constraints met except R SMG
Patient #1
R BoT/Neck / T1 N1 M0

Mean Dose (cGy)
Parotid_R 1729
Parotid_L 1544
Submandibula_R 6236
Submandibula_L 3430
OralCavity 1388
IPC 3588
Patient #2
L BoT/Neck / T1 N2b M0
Patient #2
L BoT/Neck / T1 N2b M0

GTVp_6600 100%
GTVn_6600 100%
PTV_6600 99.63%
PTV_4140 99.99%

Max dose 6814 cGy
104.2%

All constraints met except L SMG and L Parotid 2697 cGy

L Parotid Stem 939 cGy
Patient #2
L BoT/Neck / T1 N2b M0

PTV coverage isn’t sacrificed in order to meet dose constraints
Patient #3
R Tonsil/Neck / T1 N2b M0
Patient #3
R Tonsil/Neck / T1 N2b M0

Node criteria:

>1.5 cm long axis
>1 cm short axis
>0.5 cm if retropharyngeal node
Necrosis
Extracapsular extension
3 or more adjacent nodes > 0.8 cm
Short axis + long axis > 1.7 cm
Patient #3
R Tonsil/Neck / T1 N2b M0

GTVp_6800 100%
GTVn_6800 100%
PTV_6800 99.76%
PTV_4140 99.45%

Max dose 7160 cGy
105.2%

All constraints met except R SMG and R parotid 2834 cGy
R parotid stem 1862
Patient #3
R Tonsil/Neck / T1 N2b M0

Mean Dose (cGy)
Parotid_R 2834
Parotid_Stem_R 1862
Parotid_L 2088
OralCavity 3426
Submandibula_R 6375
Submandibula_L 2939
IPC 3230
Patient #3 / R Parotid Stem

Oral Cavity

R Parotid Stem
Patient #4
R BoT/Neck / T1 N2b M0
Patient #4
R BoT/Neck / T1 N2b M0

GTVp_6600 100%
GTVn_6600 100%
PTV_6600 98.35%
PTV_4140 99.9%

Max dose 6898 cGy 104.5%

All constraints met except R SMG and R parotid
Patient #4
R BoT/Neck / T1 N2b M0

Mean Dose (cGy)
- Parotid_R 2687
- Parotid_L 2057
- Submandibula_R 6391
- Submandibula_L 3549
- OralCavity 2177
- Larynx 4733
- SPC 4526
- MPC 4686
- IPC 3981
Patient #4
R BoT/Neck / T1 N2b M0

"CUTE" with the parotid

PTV_4140
0.02 cc not covered by 95% of the dose
Patient #5
R BoT/Neck / T3 N2b M1
Patient #5
R BoT/Neck / T3 N2b M1
Patient #5
R BoT/Neck / T3 N2b M1

GTVp_6600 100%
GTVn_6600 100%
PTV_6600 99.69%
PTV_5940 99.74%
PTV_4140 99.97%

Max dose 6814 cGy 103.2%

R SMG, L SMG, SPC, and R parotid not met
Patient #5
R BoT/Neck / T3 N2b M1

Mean Dose (cGy)
Parotid_R 2702
Parotid_L 1768
Parotid_Stem_L 833
OralCavity 2674
Submandibula_R 6362
Submandibula_L 4473
SPC 5734
MPC 4734
IPC 3230
Patient #6
L Pyriform Sinus/Neck / T3 N3 M0
Patient #6
L Pyriform Sinus/Neck / T3 N3 M0

GTVp_7000  100%
GTVn_7000  100%
PTV_7000    97.16%
PTV_5600    99.1%

Max dose 7377 cGy
105.4%

L parotid, Larynx, SPC, MPC, IPC not met
Patient #6
L Pyriform Sinus/Neck / T3 N3 M0

Mean Dose (cGy)
Parotid_R 1377
Parotid_L 3684
Submandibula_R 3830
OralCavity 2454
Larynx 6792
SPC 5804
MPC 6669
IPC 6153
Patient #6

L Pyriform Sinus/Neck / T3 N3 M0

Adaptive Planning

PTV_high_dose decreased from 592.2 cc to 246.0 cc → 58.5%
Thank you

Cassidy, Daughter Extraordinaire

Vladimir Feygelman, PhD

Jimmy Caudell, MD, PhD
Hope to see you!

Moffitt Cancer Center
Radiation Oncology Conference
Tampa, Florida
A Continuing Education Seminar for Radiation Therapists, Medical Dosimetrists, and Medical Physicists

January 26-27, 2018
Join us for discussions on the latest developments in Radiation Oncology
Networking/Social Event Friday Evening

Accreditation: This Program is seeking approval for 15 contact hours MDCB, ARRT, and CAMPEP. 1 hour of HIV/AIDS and 2 hours Medical Errors for Florida Licensed Physicists. Contact hours are pending final approval.

SAVE THE DATE
More information coming soon @
https://moffittradiationoncologyconference2018.eventbrite.com

For More Information:
Dawn Gintz, CMD
813-745-5768
Dawn.Gintz@Moffitt.org