Lunch Symposiums

Refining Complex Re-Irradiation Using Pinnacle Auto-Planning and PlanIQ

University Hospitals
Seth R. Duffy MS, CMD, BSPH

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Did you know?
Epidemiology of an aging population

• **Fact**: The United States population is aging.1

• Advances in medicine and greater investments in the study of public health have not only improved quality of life but also extended it.

• As dosimetrists, we may see patients returning for multiple curative-intent courses of radiotherapy.

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**Pinnacle (16.2) Auto-Planning**

Auto-Planning (AP) allows for users to create site-specific planning templates capable of mirroring optimization techniques of experienced planners.

• The iterative approach that AP utilizes allows the optimization process to continually push the entered objectives similar to how a manual planner would but without the risk of human error.

• AP would also seemingly mitigate inter-planner disparities that could exist between proficient site-specific dosimetrists and those less familiar.

• Users still have control of planning through advanced settings (“tuning balance”) where conformality and dose fall-off margin can be adjusted to meet the planner’s needs.
PlanIQ offers a unique set of dosimetry planning modules that provide users with clear feedback on optimization objectives with respect to patient anatomy and desired prescriptions.

- Calculations are both patient and energy-specific.
- “Feasibility DVHs” (FDVHs) allows for critical evaluation and modification of planning constraints prior to any optimization—having been shown to improve plan quality\[2\].
- Previously shown to improve plan quality\[1\], dose-prediction modeling and plan review tools provide dosimetrists avenues to drive treatment planning in meaningful ways.
  * Explained further on slide 14

Feasibility analyses are currently being used in clinical workflows for treatment planning of protocol patients:

- **NRG GU-005**
  Hypofractionated IMRT vs. SBRT for localized Intermediate Risk Prostate Cancer

- **Case-12806**
  Radiosurgical Approach (SBRT) for Kidney Tumors in Poor Surgical Candidates
Treatment planning for patients who have previously completed course(s) of radiotherapy can be challenging regardless of experience level.

### Dosimetric Considerations in Re-Irradiation Planning

#### Previously Delivered Dose and New CTs
- A dose accumulation, fused to the new planning CT, allows physicians and dosimetrists to understand what the potential dangers are in planning a new treatment.
- Is an EQD2 necessary given the dosing schemes used?

#### Beam Selection and Focused Optimization Objectives
- Beam arrangements (coplanar/non-coplanar), collimator rotation, control point spacing, and dosimetrist-specific optimization structures / rings.
- What planning objectives will be used? (NRG, QUANTEC, etc.)

#### Fine Resolution Dose Grid
- Setting a dose matrix that is capable of accurately calculating / displaying steep dose gradients, similar to what is done for SBRT, is highly recommended.
Drawbacks to Manual Planning

- May take numerous trials and attempts to achieve a desirable plan (very time consuming).
- Uncertainties of how the prescription and patient’s anatomy relate to generic objectives (blind optimization).
- Perhaps necessitates multiple trials at multiple prescriptions to find the necessary balance of coverage and sparing.
- Is a desired prescription even feasible to begin with?

Adaptation When Re-irradiation Complicates Planning

- Cases vary drastically from one case to another - both anatomy and previously delivered dose distributions present complexities that require a flexible / adaptable planning system.
- “One size fits all” templates may provide a good starting point but lack deeper insight into how objectives and previous dose interact.

Use PlanIQ feedback to supplement AP when pre-optimization uncertainties dominate our decision making!
What if I told you...

Pinnacle AP with PlanIQ can consistently produce re-irradiation plans of equal or greater quality when compared to manual planning.\(^{[10]}\)

"Refining complex re-irradiation planning through feasibility benchmarking and analysis for informed treatment planning"  
— S. Duffy, J. Shaverlak, Y. Zhang, M. McBride, R. Ellis

Clinical Research Utilizing PlanIQ for Re-Irradiation

Exploring PlanIQ’s versatility and expanding its scope of application.
An initial retrospective patient selection (n=10) included a diverse range of re-irradiation cases to be planned using PlanIQ-AP integration.

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial / H&amp;N</td>
<td>20%</td>
</tr>
<tr>
<td>Thoracic / Spine</td>
<td>30%</td>
</tr>
<tr>
<td>Skin / Extremities</td>
<td>10%</td>
</tr>
<tr>
<td>Abdominal / Pelvis</td>
<td>40%</td>
</tr>
</tbody>
</table>

We have continued to expand our research to (n=11) as our institution has had more time to utilize PlanIQ while maintaining diversity among the study population.

**Methods and Materials:**

**Dose Accumulation**

Previous treatment planning CT was fused to the new CT using MIM.

- Previous dose was transferred to the current scan
- For multiple previous courses all the previous dose was transferred to the current scan and a dose composite was created.

Specific isodose lines of interest were converted to contours and transferred to Pinnacle.

- Necessary to create overlap-specific objectives for PlanIQ.
Methods and Materials: OAR Segmentation

How will PlanIQ and AP differentiate between areas previously treated at different doses?

- Previous dose in the form of ROI contours act as a surrogate for accumulated dose cloud(s) on the new CT.
- Dosimetrists can segment overlap regions with corresponding dose limits to provide PlanIQ a starting point for feasibility analysis.
  - Note: OAR segments do not replace the structure as a whole under any circumstances and thorough review of all OAR is necessary.

Methods and Materials: UH Dose-Objectives

UH physician’s dictate patient-specific objective criteria for every case.

- Treatment objective sheets (seen right) are used for every patient - detailing the prescription, dose constraints, and special instructions for planning.
- Dosimetrists can enter these outlined objectives directly into AP and PlanIQ.
- If you, or a physician, consistently use a set of objectives and they are working well – save them into the AP protocol library to improve efficiency in future planning.
Methods and Materials: Protocol Dose-Objectives

What if a constraint is not explicitly indicated by the treating physician?

Applicable NRG/RTOG protocols, QUANTEC, or AAPM TG guidelines are generally used as a starting point.

- Saving protocol dose objectives to the Pinnacle Scorecard and AP technique library can save dosimetrists and physicians significant time during the planning and review processes.

- Understanding the relationship between the previously delivered dose(s) and the proximal OAR is necessary to determine our objectives at the onset of optimization...

Asking The Right Questions

When we provide AP / PlanIQ with objectives specific to the dose overlap regions we can analyze whether a critical threshold will be exceeded and ultimately whether re-irradiation is possible under a given prescription.
**PlanIQ and Pinnacle Integration**

- AP objectives are exported directly to PlanIQ.
- Critical OAR are given a “Goal Feasibility” of [Probable], [Challenging], [Difficult], or [Impossible].
- Specificity is your friend – enter all desired objectives.
- Quick processes that are user-friendly and easy to learn.

**Informed Treatment Planning from Feasibility Feedback**

Every critical OAR that has a specified dose objective in AP will also have a “Feasibility DVH” (FDVH) – similar to those on this slide.

**Interacting with FDVHs**

- Dosimetrists can use a slider bar (seen below) to adjust each OAR with respect to the type of objective (mean dose, max point dose, or a specific dose-volume constraint).
  - These changes will be directly reflected in the AP after each refinement is made and exported.
- Dose thresholds are easily observed within a given FDVH.
Describing Curves in Feasibility Spreadsheets

DVH lines are described using “F-Values”.

- The area within the green range represents \( F \geq 0.51 \).
- The area between \( F = 0.5-0.11 \) is yellow.
- \( F = 0.1-0.01 \) denotes the orange area.
- Under the red line \( F < 0.01 \) we see values that are not achievable under 100% target coverage conditions.
- The dashed line represents the predicted dose to a given structure.

Understanding F-Values is crucial to creating treatment plans that are both balanced and ultimately achievable/deliverable.

Developing a Template for Re-irradiation Cases

UH Dosimetry pioneered this method to provide continuity throughout our research as well as guiding others who may look for a starting point using PlanIQ.

- [1] For objectives with initial \( F<0.01 \) the objective was left “as is” which may necessitate some form of under-coverage of the target volume.
- [2] Objectives determined to be of \( F = 0.01-0.11 \) were also left “as is” due to their challenging status at prescription level target coverage.
- [3] If the initial \( F = 0.12 - 0.5 \) then the user’s request was to achieve the upper 25% of that range’s difficulty, specifically \( F=0.24 \).
- [4] Lastly, if \( F \geq 0.51 \) then the request was set to \( F=0.49 \), to fall just inside the challenging range.
“All re-irradiation cases were successfully predicted to be achievable per PlanIQ analyses...[and] at the same time, PlanIQ consistently produced plans of equal or greater quality to the previously manually planned” trials.

- The subset of patients that required cranial or spinal re-irradiation exhibited the greatest improvements in max point doses – **Upwards of 10.9%**.
- Seen to the left, PlanIQ was able to generate steeper dose gradients than manual planning – thus better sparing critical OAR in this patient.
Example: Recurrent Pontine Glioma – slide (b)

Manually Planned

PlanIQ Planned

PTV and GTV coverage exhibited slight improvements with PlanIQ and AP.

All optic structures showed marked improvements in both max point doses and mean doses.

Excess cochlea dose was mitigated without sacrificing target coverage.
Example: Recurrent Post-Op Prostate / Pelvic Nodes – slide (a)

- Pelvic cases, much like CNS cases, optimized into slightly more heterogeneous plans.
- Low isodose ranges seemed to be more conformal when utilizing AP techniques.
- Our DVH, next slide, illustrates improved critical OAR doses here as well.
• This dose painted plan achieved similar levels of coverage for both PTVs, albeit a hotter overall plan.

• While rectal doses were similar/unremarkable, the bladder and bowel mean/max doses were drastically improved.

• Max point doses to the femoral heads was reduced roughly 50%!

Example: Mediastinal / Neck Recurrence – slide (a)

• Lung cases took the longest to optimize when compared to plans with less air / more normal tissue surrounding the targets.

• Visual inspection would present the planner with two seemingly similar plans – again the AP is slightly more heterogeneous.

• What does the DVH show?
Example: Mediastinal / Neck Recurrence – slide (b)

Manually Planned

PlanIQ Planned

• PTV coverage was nearly identical with an improved minimum GTV coverage.

• Right, left, and total lung doses did not show room for improvement compared to manual planning techniques.

• Spinal canal, previously treated cord, and larynx were by far the most improved OAR overall.
"Total Proximal OAR" consists of all contoured OAR within any dose overlap from previous treatments. These improvements, while not statistically significant at (p=0.05), are still an improvement when compared to manually planned cases.

- Mean doses to proximal tissues were found to be an overall 2.57% improvement.
- Similar PTV coverage was required in all cases, manual and PlanIQ generated.
- Nine of eleven [9/11] patients have exhibited an improvement with the largest being a 7.7% reduction with PlanIQ.

Planning timetables are verified via MOSAIQ timestamps for contour completion to final plan review. Time for planning CT import, Image fusions, and contouring were not included for either planning method.

- While not a primary metric of our initial study, recorded planning times were significantly less when utilizing PlanIQ.
- PlanIQ consistently produced plans of equal, or greater, quality while also reducing planning time by an average of ~10 hours.
- Incorporating PlanIQ into planning for re-irradiation cases became almost second nature with our consistent template.
PlanIQ and Auto-Planning (AP) Integration

- At this time, PlanIQ does not support dose summation between a DICOM file and the feasibility modeling system.
- If it were possible to export a previous treatment dose to PlanIQ, upon which the feasibility analysis could provide benchmarking of our new objectives and the prior dose – we could eliminate manual OAR/dose segmentation and reduce possible human error further.

Differentiating between 100% PTV coverage and acceptable coverage for overlapping OAR can be tricky because PlanIQ and AP are two separate applications at this point in time.

- Institutional standards *may allow* for 95% coverage of the PTV at prescription depending on the case.
- PlanIQ calculates feasibility at 100% target coverage.
No two re-irradiation cases are ever going to present with identical anatomy and previous dose clouds. Theoretically this would result in library-based optimization tools being less effective in planning cases where they will be far less likely to have a comparable plan to draw upon.

PlanIQ is capable of calculating real-time answers to complex questions – dosimetrists just need to provide the OARs and dose objectives.

Key Points & Wrapping Up

PlanIQ and AP as a benefit to Dosimetrists

- Utilize dose prediction tools to determine whether re-irradiation is possible under the given circumstances.
- Eliminate pre-optimization uncertainties through objective benchmarking and dose cloud visualization before you begin planning.
- Feasibility analyses allows us to set smart objectives that are not in conflict with what is actually achievable.
- Optimize plans with confidence that the auto-planning technique is suitable for a variety of cases, including re-irradiation.

* Determine whether 95% coverage is acceptable per institutional standards.
Questions, Comments, or Concerns?

Don't forget to check out our poster abstract this week at the 44th annual AAMD conference!!

THANK YOU!
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PHILIPS

PowerPoint Contributors:
Jessica Muenkel MS
Rodney Ellis MD
Yiran Zheng PhD
Francisco Nunez MS

Seth R. Duffy MS, CMD, BSPH Email: SethD1989@gmail.com
References:


