Effect of Calculation Grid-size, Statistical Uncertainty, and CT Slice-thickness on treatment planning

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Disclosures

- Relevant financial relationships
  - Received financial compensation for this presentation from Elekta
Further Disclosures…

…I am a physicist
Background

• Physics BS
  – NOT APPLIED
  – What to do?
• Medical Physics MS
  – More applied
  – Unclear department workflow and connectivity
  – Admittedly low focus on Treatment Planning
    • Sadly common
    • Shortsighted, illogical

First job

• Plan checking
  – Comfort Level
  – OTJ training
• Appreciation
  – LACKING
  – Disconnect of understanding
• Expertise
  – NOT AN EXPERT
  – admit there is a missing piece
Second job

- EBRT planning
  - Start at the bottom
  - Physicist? → doesn't matter
- Appreciation
  - HUMBLING
  - In-depth understanding
- Expertise
  - Becoming an expert
  - Correct the missing piece

Third (current) job

- Back to Clinical Physics
  - Plan checking
  - Technique review
- Connecting the dots
  - (Connecting departments)
  - Putting the pieces together
  - Hands-on in dosimetry
  - Best-practices creation
  - Advocate (two-way street)
AHN Cancer Institute Locations
(23 geographically located sites with 9 comprehensive Cancer Centers)

More than 130,000 cancer treatments delivered for nearly 10,000 cancer patients. 204 physicians: 136 surgeons, 51 medical oncologists, 17 radiation oncologists.

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<thead>
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<th>Sites</th>
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<th>RO</th>
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H - Hematology - 2 sites
MO - Medical Oncology - 16 sites
RO - Radiation Oncology - 14 sites
SO - Surgical Oncology - 14 sites
CT - Cellular Therapy/Transplant - 1 site
Need for Standardization

• AHN → 14 regional sites
  – Assumption of same quality of care, same access to techniques (EBRT, SBRT, Brachytherapy, etc)
  – Clinical training/teaching

• Elekta Monaco 5 (5.5.1 August 2019 upgrade)
  – New challenges
  – New techniques

• Centralized teaching and training program
  – Same metric, methods, expected outcomes
  – Expectation of ‘knowledge propagation’
  – Basic agreed-upon parameters*

Case study

• Dosimetry:
  – “What grid size and uncertainty should we use for X plan?”
  – “What about the QA plan for plan X?”

• Physics:
  – “………..”
Basic questions

• Dosimetry → where to begin?
  • MC (grid size, statistical uncertainty, QA plans)
  • CC (grid size, CT slice thickness)

• Physics → where to find the answer?
  • Vendor information
  • Outside opinion
    – Colleagues
    – Independent studies

• Test ourselves*

Monte Carlo

• Patients: H&N, Brain, SBRT Lung
  • 1mm, 2mm, 3mm grid size
  • 1% per calc, 3% per control point SU

• Comparison
  • Dose plane from Monaco TPS
  • DVH statistics for PTV and OARs
  • Time for calculation
Collapsed Cone

- **Patients:** H&N, Brain, SBRT Lung
  - 1mm, 2mm, 3mm GS
  - 1.5mm, 3mm CT slice thickness (H&N and SBRT Lung), 1mm, 2mm, 3mm (Brain)

- **Comparison**
  - Dose plane from Monaco TPS
  - DVH statistics for PTV and OARs
  - Time for calculation

### Monte Carlo Results

- Calc time or 3D MC:
  - Longest time was 8min 30sec
  - Shortest was 7sec

3D fields, MC forward-calculation
Monte Carlo Results cont.

 VMAT fields, MC calculation

- Calc time VMAT MC:
  - Longest was 1 hour 9 mins
  - Shortest was 35 sec

3D MC

IMRT MC

- SNC Patient software
  - Version 2.0
- Dose planes exported and analyzed
  - Sagittal
- Compared to 'clinical standard'
  - 3% pcp, 3mm GS
Monte Carlo Results (cont)

- Dose Planes
  - 100% of points agreed 3%3mm and 2%2mm
  - 94% agreed 1%1mm
- DVH statistics
  - mean dose for all structures within 1%
- Calc time (VMAT)
  - Longest (H&N, 1mm GS 3% pc) was 1 hour 9 mins
  - Shortest (Lung, 3mm GS 1%pcalc) was 35 sec
- 1mm GS: too much noise
### Collapsed Cone planar-array dose comparisons

<table>
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<tr>
<th>SNC Cone Type</th>
<th>Dose Planes</th>
<th>Sagittal</th>
<th>Compared to 'resolution standard'</th>
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<tr>
<td>Version 2.0</td>
<td>99%</td>
<td>96%</td>
<td>Smallest CT Slice thickness</td>
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<td>96%</td>
<td>96%</td>
<td>Smallest GS</td>
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**Calc Time**
- Longest calc time (1mm GS H&N 3mm slice thickness) was 2.5 mins
- Shortest (3mm GS brain 3mm slice thickness) was 7 seconds

### Collapsed Cone Results (cont)

- **Dose Planes**
  - 99% of points agreed 3%3mm (one at 95%)
  - 96% passed at 2% 2mm (most above 99%)
  - a minimum of 52% agreed 1%1mm

- **DVH statistics**
  - mean dose for all PTVs was within 1.5%
  - Other OARs varied by up to 11%

- **Calc Time**
  - Longest calc time (1mm GS H&N 3mm slice thickness) was 2.5 mins
  - Shortest (3mm GS brain 3mm slice thickness) was 7 seconds
Conclusions

• Monte Carlo
  – No gain for smaller grid size, longer calc time (DOSIMETRY)
  – Some indications for superficiality and small volume

• Collapsed Cone
  – Minimal time gain for smaller grid size, but points to higher accuracy (DOSIMETRY/PHYSICS)
  – Raises new questions:
    » Some indications for small volume?
    » Number of points (varies by slice thickness)
    » Slice thickness study

Recommendations

• Dosimetry
  • Technical
    – For MC plans, 3mm grid size is appropriate for >95% of cases
    – 1% pcalc is adequate, can go to 3%pcp, may tighten up idls, lower max hotspot
    – Can and should use the same criteria for QA plans
    – For CC plans, smaller is usually better
  • Practical
    – Time to calc and throughput of patients
    – Trusting our information → retreat cases, OAR constraints
    – Standardized starting points, comparison of outcomes, coherent training, evaluation*

• Physics
  • Plan-checking
  • Cross-coverage
  • Expectations/assumptions of standardization
Raises new Questions

- Physicist colleague
  - Calculating ≠ Optimizing!!
  - Back to the drawing board

- New investigation
  - Birds-eye view
  - H&N only (more disease sites to follow)
    - 3mm, 2mm GS
    - 1% pcalc, 3% pcp, 2% pcp
    - Start of optimization → end, no changes to Opt Parameters

Preliminary conclusions

- Comparison to ‘recommended standard’:
  - Four-fold time increase maintains
  - Planning is more than calcing
  - PAY ATTENTION, PHYSICS
1% pcalc vs 3% pcp

- Elekta training
  - Start with 1% per calculation
  - Move to 3% per control point
    - If close to OAR constraints
    - If global max to high
    - If IDLs need tightening
    - If time-permitting*

- Time effect
  - H&N case, 3mm GS
  - 7 mins longer
  - Worth the time?

Further investigation

- Full optimization time study
  - More disease sites
  - Dose accuracy comparisons

- CT slice thickness study (ongoing)
- Correlation of points with dose agreement
Need for Standardization (revisited)

• Competency and Credentialing Program
  – Accountability
  – Cross-coverage
  – Knowledge propagation

• AHN program
  – Dosimetry-driven
  – Task based
  – Individual spreadsheets → Master Spreadsheet (administration)

Elekta Standardization

• Automated Planning
  – Protocol Driven
  – Scorecard → ‘traffic light’
  – Multicriterial Optimization (MCO)

• Centralized Server
  – Beam data management (physics)
  – Planning efficiency (calculation speed)
  – Administrative benefit
Conclusion

• Dosimetry/Physics
  • Larger system → communication/expectation
  • Inter-department Cooperation
  • Problem-solving
    – Identify clinical issues → loss of efficiency/poor outcomes?
    – Research → don’t reinvent the wheel…
      …but don’t trust it unless you’re comfortable with the source
    – Use tools at your disposal to address the problem
    – Make coherent, concise recommendations
    – Reinforce practice
  • Always be improving

Special Thanks

AHN Physics and Dosimetry
  – Brian Leicher, CMD
  – Lisa Spanovich, CMD
  – Dan Pavord, MS
Special Thanks

Elekta
– Anthony Brown
– Brad Read
– Stephanie King
– Randy Larson

Thank you

• Questions?
Lunch Symposium passcode

546