Quality Concepts in Minimum Practice Guidelines for TPS Dosimetric Commissioning (TG-244)

Vladimir Feygelman

Department of Radiation Oncology
Moffitt Cancer Center
Tampa, FL

Disclosure

- Co-author TG-244
- Sponsored Research Agreement – Sun Nuclear Corp.

Dual aspects of quality in TG-244

- Quality of plans used for IMRT/VMAT commissioning
  - Attempted to reflect the complexity and quality of plans expected to be used clinically
- Quality of dosimetric agreement across the range of plans

TG-244 is currently under public comment period

Plans

- Test plan strategy follows the progression from simple to more complex
- After component testing, the first two plans are from TG-119: H&N and C-Shape

Plans (ctd.)

- The rest of the plans are those from Plan Challenge
  - Downloadable from the TG-244 site: CT, Contours, Objectives/Constraints
  - Between the lines idea is to construct a plan with a decent Quality Score, which would assure substantial modulation
  - Unlike TG-119, sizable targets

Plans (ctd.)

- A menu of 5 plans
  - The Report recommends at least the two of:
    - H&N (SIB)
    - Abdomen (SIB)
    - Anal (SIB)
    - Lung (PTV 767 cc)
    - Prostate bed (SIB)
  - I would suggest H&N and either Abdomen or Anal as a minimum, to test the high modulation and large targets
  - If split fields are in the picture, they need to be tested

Closing the loop

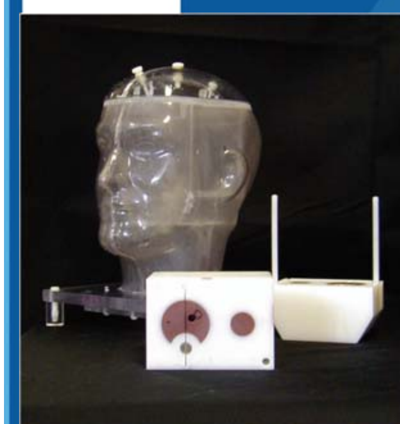
TG-244 calls for an independent end-to-end dosimetric test in an anthropomorphic phantom

- Available from RPC on a fee-for-service basis, regardless of protocol participation
- At least H&N
- Additionally, Thorax if part of practice

Closing the loop

Credentialing results from IMRT irradiations of an anthropomorphic head and neck phantom

Andrea Molineu,[a] Nadia Hernandez, Trang Nguyen, Geoffrey Ibbott, and David Followill
Department of Radiation Physics, The University of Texas MD Anderson Cancer Center, Houston, Texas 77030



- 4TLDs in primary PTV, 2 in secondary PTV and OAR each
- Threshold ±7%
- Film in axial and sagittal planes
- Threshold 4 mm DTA

Paper vs. deliverable quality

- In real world, those could be somewhat contradictory
- The plan can beautifully meet all the objectives on paper but become so complex that substantial differences develop between the delivered and calculated dose
- Thorough, accurate commissioning is essential

The take home message

The more effort is put into commissioning the system, the more likely that the best quality plan would deliver the best actual dose distribution

What are the TG-244 dosimetric accuracy recommendations?

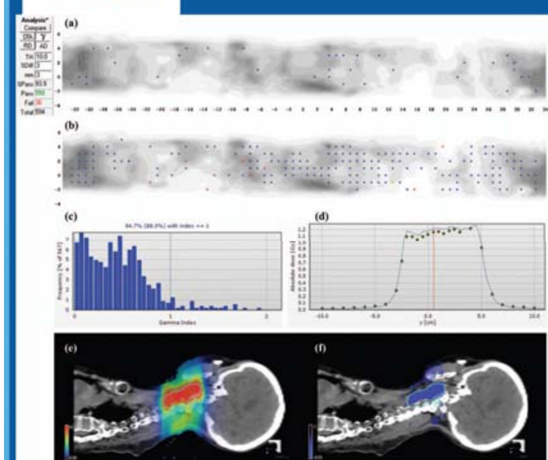
Point doses

- Ion chamber is still the required gold standard
  - Average error < 2% (1.5% preferred in the PTV)
  - In the OAR, within 5% normalized to Rx dose. Evaluation by local normalization also recommended

Dose distributions

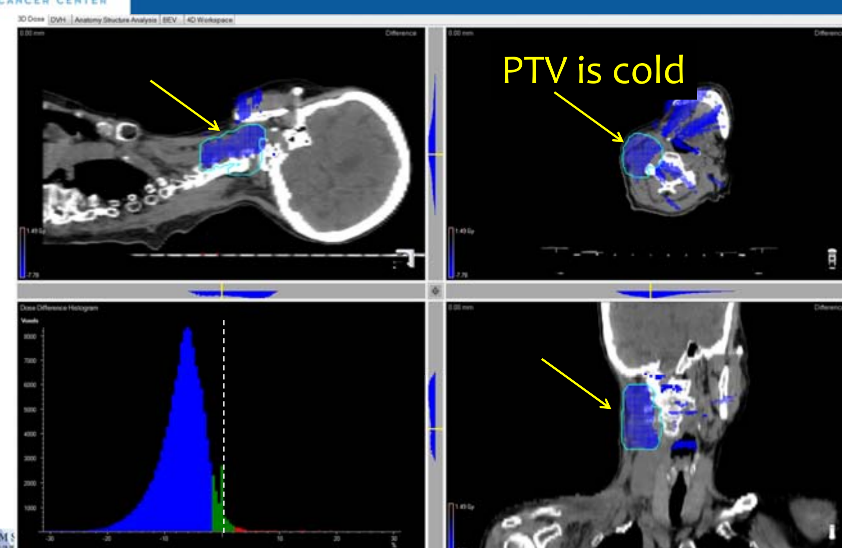
- For dose distributions, can use film or electronic dosimeters ***if*** appropriate spatial resolution can be achieved
  - This is a departure from previously published papers stating that only film provides adequate resolution
- Investigate dosimetric agreement at 2%/2mm level.
  - This is a departure from a *de facto* standard set by TG-119
  - No fixed "pass rate" prescribed
  - Look for common patterns of failure

A real-world example

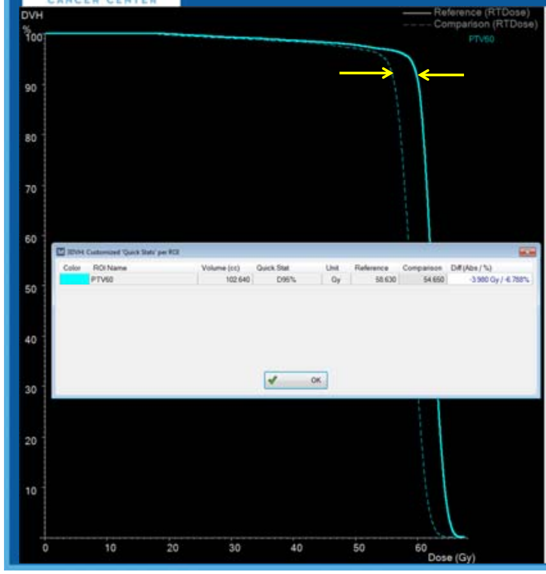


- H&N re-irradiation
- 2 Arcs
- What we thought was a well-commissioned VMAT TPS
- Passed QA with standard γ(3%**G**/3mm) analysis

Dose-difference



PTV DVH error



- PTV D95 is 7% low

What happened?

- MLC apertures are too narrow
- Any algorithm will eventually break as the segment width decreases
- Again, a clear error is hidden by applying 3%/3mm criteria to the entire volume
- No easy remedy, but at least can be tracked/avoided

Another possible pitfall

- Lung SBRT
- RTOG protocols strictly enforce dose compactness

Intermediate dose spillage – different RTOG protocols

Rapid dose gradient beyond the PTV

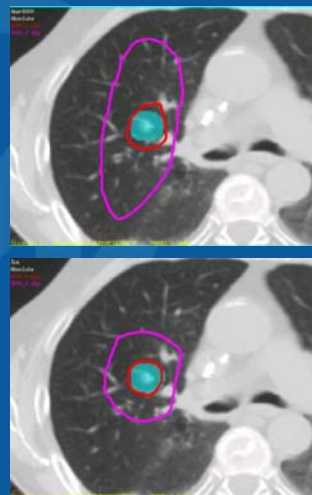
- Limit dose 2 cm from PTV to ***X % of Rx*** (50 to 77)– depends on PTV size (avoid dose polarization)

PTV Volume, (cc)	Max Dose @ 2 cm from PTV as % of Rx	
	Perfect	Minor Violation
1.8	<50.0	<57.0
3.8	<50.0	<57.0
7.4	<50.0	<58.0
13.2	<50.0	<58.0
22	<54.0	<63.0
34	<58.0	<68.0
50	<62.0	<77.0
70	<66.0	<86.0
95	<70.0	<89.0
126	<73.0	>91.0
163	<77.0	>94.0

What happens when…

…dose polarization ignored

…dose polarization addressed



Intermediate dose spillage – different RTOG protocols

Rapid dose gradient beyond the PTV

- Volume receiving *50% of Rx* / Volume of PTV is less than *Y (5.9 to 2.9)*, depending on PTV size (isotropic steep falloff – intermediate dose compactness)
  - often the hardest constraint to achieve

PTV Volume (cc)	50% Dose Volume/PTV volume	
	Perfect	Minor Violation
1.8	<5.9	<7.5
3.8	<5.5	<6.5
7.4	<5.1	<6
13.2	<4.7	<5.8
22	<4.5	5.5
34	<4.3	5.3
50	<4.0	<5.0
70	<3.5	<4.8
95	<3.3	<4.4
126	<3.1	<4
163	<2.9	<3.7

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The result

Highly modulated plans, much more so than one would expect from the casual look at the target and OARs

↓

Small apertures

↓

Unpredictable results in lung, certainly with Convolution/Superposition algorithms

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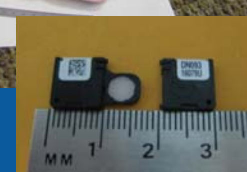
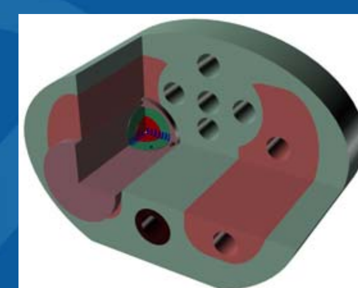
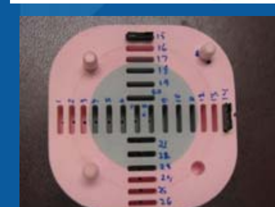
Some experimental confirmation







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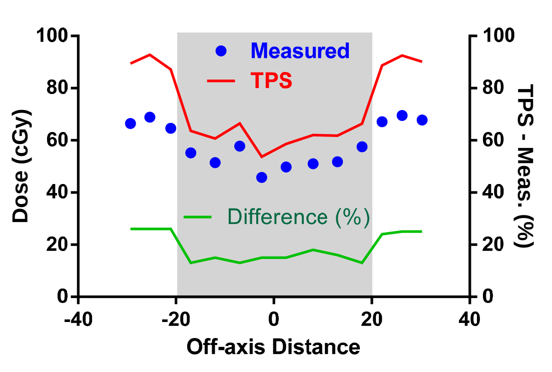
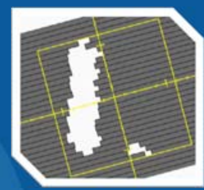
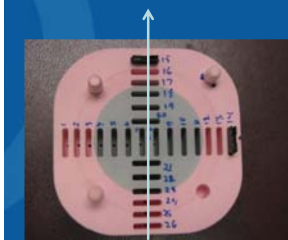
Highly modulated plan in lung (TG-119 C-Shape)







Conclusions

- TG-244 recommendations, if followed in spirit, is a step in the right direction and will help to bridge the gap between best quality plan on paper and in patient
- Comprehensive commissioning strategy and tight tolerances help in moving towards that goal
- Volumetric assessment techniques may be more clinically relevant