Radiochromic film in the Clinic,

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Contents

• Varian Rapid Arc (RA), Clinical demand for QA
• EBT2 filmdosimetry at VUmc
• Comparison of FilmQA with VUmc method
• Conclusion
Rapid Arc

- RA is “IMRT” in a **single** rotation
- Different from IMRT by optimization and delivery
  - 1 Arc with variable gantry speed (0.5 – 5.54 degree/sec)
  - Variable dose rate (0 – 600 MU/min (0 – 1000 MU/min on Novalis Tx)), (0.2 – 20 MU/degree)
  - Rapid changing MLC apertures (0 – 2.5 cm/s)
  - Minimization of Monitor Units
  - Direct Aperture Optimization (simulated annealing)
- AAA in Eclips (2.5 mm voxel)
- Inter-digitating MLC
- Highly modulated beam segments
VUmc department Radiotherapy

- 2 Varian 2300 C/D
- 1 Trilogy
- 1 Trilogy Novalis Tx
- 2 Truebeam
Implementation Rapid Arc VUmc

- VUmc is one of the first clinical users of RA in Europe (2008)
- Only 6 MV (but also SRS 6 MV 1000 MU/min on Novalis TX)
- 6 accelerators with RA
- 2 arcs per patient (CW and CCW), coll 45 and 50 resp.
- Main indications at VUmc
  - Head and neck
  - Lung
  - Brain
  - Glioblastoma
  - Prostate

Fractions x Dose [Gy]
33 x 2 Gy
12 x 5 Gy
4 x 7.5 Gy
1 x 8 Gy
5 x 8 Gy
3 x 9 Gy
5 x 11 Gy
3 x 18 Gy
Demo Rapid Arc MLC movements leading to small beam lets for intensity modulation

Collimator 45 and 50 degree
WBRT (4 Gy) + mult. metas. (8 Gy)
Clinical example of Rapid arc treatment

Multiple brain metas: SRT

- 6 cm off axis
- 2.5 cm off axis
Clinical example of Rapid arc treatment

RapidArc optimized plan for Nasopharynx with SIB (56 / 70 Gy)
Clinical example of Rapid arc treatment

Film analysis for nasopharynx, comparison with calculations
Rapid Arc

Helical MatriXX versus EBT1 film

MatriXX
Raw data

Film

Gamma 3%, 2mm
Rapid Arc

Helical MatriXX versus EBT1 film

Gamma 3%, 2mm
Difference in machine performance (i versus j)

*Machines i and j both meet “Varian specs”!*  
*Solved by re-positioning head assembly 0.3 mm*
Differences in machine performance **not detected** with MatrixX only, therefore EBT mandatory!
2.5 D gamma evaluation?

- Measured plane with 3 calculated planes, 1 mm apart:
  20 mm 19 mm 18 mm

- Uncertainty in phantom positioning
- Highly varying spatial dose distributions (within 95-107%)
2D ≠ 3D

Relativity 1953 M.C. Escher
Observation: Eclips calculates higher intensity modulation

MatriXX in VUmc phantom
Films show that the accelerator produces higher intensity modulation than calculated.
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GafChromic Film Dosimetry at VUmc

Van Battum et al. Med. Phys 35(2) 2008
and Van Battum et al. ESTRO poster 394 2009
VUmc

- Need for high resolution detector with 3% accuracy (1 SD)
  - Especially for commissioning, research, start-up RA, QA, ……..
  - EBT1 not available anymore → EBT2 (2008)
  - Film workload too big for routine pre-treatment verification, but
    - method of choice for in-homogeneous phantoms (lung)
    - method of choice in Quasar phantom
    - On demand….  
  - Routine RA-QA with MatriXX (10 – 15 patients starting per week)
  - About 10 RA patients with MatriXX; 1½ hr at linac
  - Need for fast QA with good resolution and accuracy
GafChromic film dosimetry at VUmc

- Dose plane in \textit{absolute dose}
- No extra ionization chamber measurement
- Average 2 films per dose plane (Van Battum et al. Med.Phys 35(2) 2008)
- Each pre-treatment verification; 2 calibration films
- ‘Step-shaped’ calibration film
- Derive OD to dose information (with Matrixx data)
- Home made Matlab routine (GClab)
Double exposure technique:

- To improve accuracy of EBT2:
  - Scan un-irradiated film (red channel only)
  - Irradiate film with e.g. 100 MU
  - Scan film again
  - Irradiate pre-treatment plan
  - Final scan

- Corrects for local sensitivity variations !!!
Double Exposure technique:
clinical example Oct. 2010 Truebeam
EBT2
Eclipse
3%/2mm
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GCLab vs. FilmQA (LCCR)

Gamma of GCLab vs. ‘FilmQA lateral uncorrected’

Gamma of GCLab vs. FilmQA (LCCR) corrected

Gamma 3%, 2mm
EBT2
GCLab DE vs. FilmQA with lateral correction
Remarks for Double exposure

- Film dosimetry with Double exposure is;
  - Cumbersome
  - Only applicable for one or two patients a week (complex, SRS)
  - For routine QA we have to check 10-15 patients per week
  - Time available in accelerator is limited (<2 hrs per QA slot)
  - MatriXX information on Dose is OK (spatial resolution is poor)
  - Dose range EBT2 limited (<10Gy) (Green channel??)
  - How about absolute dose information?????? (Future work)
Remarks of Matrixx

- Spatial resolution poor
- Gantry sensor (corrects for directional dependence)
- One single plane per patient (*central phantom*)
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Conclusions

• Rapid Arc accurately delivers the planned dose distr.
• Higher spatial dose modulation observed with film
• Eclipse calculates smoother dose distributions than measured
• Dosimetry verification with film preferred over MatriXX
• 2.5D gamma evaluation would give better agreement

• Pre-treatment verification
  – Discussion if every patient needs to be measured
  – If so, with what accuracy (detector)
  – Epid (Epiqa, Civco, home made?)
  – Risk analyses
  – Total QA program; ongoing process….
Conclusions

- Film dosimetry for spatial resolution!
- Local QA strategy
- Film-QA gives excellent agreement in comparison to Matlab
- Workload at VUmc limited
- For Varian users Film is a powerful tool
- Absolute dose information is important
Thank you for your attention

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