EBT2/EBT3 with FilmQA Pro
St Luke’s Radiation Oncology Network
Overview

1. Rapidarc plan verification
   - Prostate
   - Head & Neck

2. Commissioning
   - Treatment plan verification
   - Algorithm tests – inhomogeneities
   - Measurement of interleaf leakage

3. Research
   - Cell survival study

4. Future work
   - Commissioning of stereotactic system
   - Investigation into out-of-field doses
   - A study on small field dosimetry
1. Rapidarc plan verification

- Increased degrees of modulation present in RapidArc delivery:
  - MLC are continuously moving
  - Gantry speed & dose rate are variably modulated

- New methods and tools are required for patient specific QA
  1. ArcCHECK
  2. Gafchromic film measurements for validation and as a backup for arcCHECK.
1. Rapidarc plan verification

- ArcCHECK is a commercial diode array designed specifically for rotational measurements.
  - 1386 diodes, depth = 3.3cm, 10mm spacing, spiral design
1. Rapidarc plan verification

ArcCHECK – plan assessment
1. RapidArc plan verification

- ArcCHECK - confidence limit
- From the commissioning plans the confidence limit is 96.2%. (for gamma criteria of 3% 3mm, Threshold =10%)

Average = 97.7%

Pass rate should equal 96.2%, for 95% of the measurements.

Ezzell et al., 2009
1. Rapidarc plan verification

- Gafchromic film
- Advantages:
  - High spatial resolution
  - Weak energy dependence
  - Near-tissue equivalence
- Disadvantages:
  - Images suffer from a ‘lateral’ artifact and other problems related to scanning
  - Other non-dose-dependent artifacts including variations in thickness of film active layer

Solution: Use triple channel dosimetry to separate dose-dependent and dose-independent parts of scanned film
1. Rapidarc plan verification

- Axial dose planes
- Coronal dose planes
1. Rapidarc plan verification

Assessment using FilmQA Pro software
1. Rapidarc plan verification

Gafchromic results

Average 97%
2. Commissioning – plan delivery

- **Prostate plan**
  - 4 field 3D conformal plan with MLC and EDWs.

- **Measurement set-up**
  - A 20cm block of WEP was set to SSD = 90cm.
  - EBT3 Gafchromic film was placed at isocentre (10cm depth). Plan delivered at planned gantry angles.
  - Analysis was performed using FilmQA Pro software.
2. Commissioning – plan delivery

- Profiles through the central axis.
2. Commissioning - Algorithm tests

- The ability of the AAA algorithm to account for inhomogeneities was tested using Gafchromic EBT3 film in the CIRS phantom.
2. Commissioning - Algorithm tests

- Gamma analysis was used in order to ensure film was aligned with dose plane from TPS.

- Disagreement is evident in build-up region and at inhomogeneity interfaces.
2. Commissioning - Algorithm tests

- **Validation of absolute dose**
  - To validate the calibration of the film, a 0.125cc semiflex chamber was used.
    - Dose of 150.1cGy was measured at 10cm deep in water equivalent part of phantom.
    - Dose values of 142.0cGy and 133.2cGy were calculated for the beams which traversed the bone and lung inserts respectively.
2. Commissioning - Algorithm tests

**Cirs phantom - Water**

- **Gafchromic film**
- **Chamber measurement**
- **TPS**

**Film at dmax = 209.6 cGy**
**TPS at dmax = 208.7 cGy**

**Chamber at 10 cm = 150.1 cGy**
- 0.6% higher than film
- 0.1% higher than TPS

**Apparent shift in buildup region = approx 2.4 mm**
2. Commissioning - Algorithm tests

Cirs Phantom - Bone insert

- Gafchromic film
- Treatment plan

Chamber at 10cm = 142.0 cGy
2.8% higher than film
1.4% higher than TPS

Film at dmax = 208.1 cGy
TPS at dmax = 210.6 cGy
% difference = 1.2%
Film inside bone = 198.6
TPS inside bone = 188.3
% difference = 5.1%

Dose (cGy) vs. Depth (mm)

Bone insert

Dosage point
2. Commissioning - Algorithm tests

CIRS Phantom - Lung insert

- Gafchromic film
- Gafchromic adjusted
- Treatment plan

Film inside lung1 = 171.1 cGy
TPS inside lung1 = 171.3 cGy
% difference = 0.1%

Film inside lung2 = 90.2 cGy
TPS inside lung2 = 89.4 cGy
% difference = 0.9%

Chamber at 15cm = 133.2 cGy
2% higher than film
3% lower than TPS
2. Commissioning - Algorithm tests

Summary

- We observed an overestimation of dose beyond inhomogeneities for 10MV:
  - Bone ~1%
  - Lung ~3%
- Previous commissioning work for 6MV gave similarly overestimated doses beyond inhomogeneities:
  - bone ~1.5%
  - Lung ~3.5%
- Van Esch et al., measured point doses beyond lung and cork:
  - Dose overestimated beyond lung by 4.7% and 3.4% for 6MV and 15MV
  - Dose overestimated beyond cork by 7% and 2.5% for 6MV and 18MV

2. Commissioning – interleaf leakage

- **Recommended measurement:**
  - Central axis cross-plane profile for T-shaped field shown here

- **Measurement conditions:**
  - Gafchromic Film (EBT2)
  - 90 cm SSD, 10 cm deep
  - 1000 MU irradiation
  - Backscatter > 10 cm
  - Gantry 0°, Collimator 90°

- **Analysis software:**
  - FilmQA Pro
2. Commissioning – Interleaf Leakage
2. Commissioning – interleaved leakage

Values of ILL = 0, 0.012, 0.015, 0.016, 0.017, 0.018

Elekta SynergyX, 6 MV Photons, No modifier
16.00 x 16.00 cm, BLD angle = 270°, SSD = 90.00 cm, (Z) 10.00 cm

Relative dose vs Position in X direction [cm]
2. Commissioning – interleaved leakage

Elekta SynergyX, 6 MV Photons, No modifier
16.00 x 16.00 cm, BLD angle = 270°, SSD = 90.00 cm, (Z) 10.00 cm
3. Research – Cell survival study

- A study focussing on the ‘Bystander effect’ led by DIT
  - Tissue and blood samples from treated cancer patients are irradiated to low dose levels (0.05Gy and 0.5Gy)
  - Individual patient radiosensitivity can be investigated

- Gafchromatic film is used:
  - To help us design the experimental set up.
  - To determine the exact dose level being delivered to the cells.
4. Future work: Stereotactic commissioning

- Varian Trilogy linac commissioning for stereotactic treatments
  - Accurate measurement of small fields (0.5cm x 0.5cm) is required
    - We propose to use gafchromic film in a water tank.
    - We will need a specialised holder in order to be able to accurately place the film within the tank.
4. Future work: Research

- Accurate measurement of out-of-field doses
  - Using Gafchromic to measure out-of-field doses (<2Gy) and compare to TPS and Monte Carlo

- Small field dosimetry
  - Using Gafchromic to measure small fields (<0.5cm) and compare to TPS and Monte Carlo
Acknowledgements

- All staff at St Luke’s in Rathgar, Beaumont and James’s.
- Andre Micke and David Lewis for all their work on gafchromic film and FilmQA Pro software.
- Ann Martindale from Perlamar for organising the workshop.

Thanks for listening!