**Best Practices with Radiochromic Film**

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**Outline**

- Where we are in radiochromic film dosimetry
- Introduction to radiochromic film
  - Different types of radiochromic film
  - Best practices with radiochromic film
- New radiochromic film dosimetry
  - Multichannel film dosimetry
  - One-scan dosimetry protocol
  - Clinical samples of multichannel film dosimetry
    - IMRT/VMAT, SBRT/SRS commissioning/QA
    - In-vivo dosimetry

**Gafchromic Films**

- Self-developing film
  - Eliminates processor
  - Can handle in room light
  - Can cut to size & bend to shape
  - Can immerse in water
- Wide dynamic range
- High spatial resolution
- New software and protocol make film use much more accurate and user-friendly

**Films for Dose Measurement**

- Radiotherapy (MV photons/elektron/protons)
  - EBT2, EBT3, EBT-XD – 1 cGy to >40 Gy
  - HD-V3 – 2 Gy to 300 Gy
  - HD-V2 – 10 Gy to 400 Gy
- Radiography (kV photons)
  - XRQA2 – 1 mGy to 20 cGy
  - XRQT2 – 1 mGy to 20 cGy
  - XRM2 – 1 mGy to 20 cGy

**Best Handling of Radiochromic Film**

- Film
  - Store in the dark, at temp. < 25°C, humidity < 50%
  - Avoid dust, fingerprints, or crimping
- Film Scan
  - Scanner type
  - Scanning procedure
  - A piece of glass to press the film flat
  - Inter-scan variation (orientation, location on scanner)
  - Ambient temperature/moisture change
  - Post-exposure film density change

**Equipment and Tools**

- Varian Trilogy Linacs (3)
- GammaMedplus™ IX HDR
- Memorial Sloan-Kettering IMRT/VMAT TPS
- Eclipse™ and iPlan™ TPS
- GafChromic EBT3 film
- FilmQA™ Pro
- Epson 10000XL flatbed scanner
- GafChromic Quick™ phantom
- Two slabs of 5-cm thick Solid Water
Orienta(on Dependence

Either orientation is usable
Be consistent!

Response error is ~0.05% per degree
Dose error ~0.15% per degree

Scanner response
Rota(on Angle

Scan direcIon

Single (red) channel dosimetry

A systematic approach
Multichannel film dosimetry
- Removes local disturbances
- Achieves better calibration function
- One-scan dosimetry protocol
  Eliminates inter-scan variability
  Avoids environmental effects (e.g., temp.)
  Corrects for post-exposure density growth

RGB Calibration Curves
Dose-induced color C
(D0 - (D0.D)/D0)
Dose exposure generates only certain colors C
intensity of color C

Calibration Fitting Functions

Polynomial Functions
X(D) = \sum_{i=0}^{n} A_i D^i
where D = dose, X(D) = response

Rational Functions
X(D) = A + B/(X(D) - C)
Consistent with the behavior of film
Easily inverted

Multichannel Film Dosimetry

Polynomial Functions
CalibraIon FunctIons
Consistent with the fundamental properties of film
Function can provide dosimeter values
Cannot be executed

Linear Relations
Calibration in FilmQA Pro

"One Scan" Film Dosimetry

"One-scan" Protocol
- All dose response curves have similar shape
- Scan the patient and reference films together
- Two-point re-scaling: one exposed reference plus an unexposed film - applies to most situations
  - Post-exposure change
  - Inter-scan variation
  - Ambient temp/humidity change
  - Type of scanner used
  - Film-scanner orientation
- Ability to obtain accurate results in minutes

Deal with Post-exposure with One-scan

When $t >4\Delta t$ (min) the dose error <0.5%

Linacs / Eclipse / iPlan Commissioning

Exposed QA film using "One-scan" Protocol
2/17/2014

Two ref. doses: 300 cGy and zero - Calibration was done 12/13/2013 - IMRT film QA was 2/17/2014

For in-house software: the triple-channel dose map can be exported with a scaling factor: $D_{max}/65536$

Linac, TPS, HDR Commissioning & QA

Lutz - Parallel-Opposed Fields
Flat Beam Test - Eclipse, VP, C tutor, TPS, etc. 4/16/08 - 3/13/09

Field Matching / Asymmetric Jaw QA
PD profiles (d<2mm) for 6X, 10x10 cm$^2$ (EBT vs. Monte Carlo simulation)

Lutz - Parallel-Opposed Fields
Lesions:
195% (63Gy)

WB:
100% (32.25Gy)

Hippocampi:
18% (<6Gy)

Eclipse TPS v11

QuiCk Phantom
30x30x10 cm 3
2-arc VMAT

FilmQA Pro
1200cGy x 4 = 4800cGy
1000cGy x 5 = 5000cGy
900cGy x 5 = 4500cGy

Dmax ~ 1420cGy
Pass rate is 99%
for 2%/2mm

Brachytherapy Dosimetry

Sr-90/Y-90 Disk-shaped Source

One-scan Protocol in Brachytherapy

Lateral Scanner Position – Multichannel

Trial Brachytherapy Dose Distribution

In Vivo Dosimetry

EBT2/EBT3 for Superficial Region Dosimetry

Patient Skin Dose Measurement


- Courtesy of Tony Palmer, University of Surrey, UK
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