A Dosimetric Audit of IMRT in the UK

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Aims of Audit

• Independent check on the safe implementation of IMRT in the UK and identify problems in the modelling and delivery of IMRT.

• Act as a pre-clinical independent check for centres starting IMRT or moving to new treatment sites.

• Provide a snapshot of the range and complexity of IMRT being practiced in the UK.

• Satisfy the need for independent IMRT audit methods being proposed in national guidelines and standards.

• Generate published data presenting the results of the audit to the radiotherapy community.
Principles of Audit

• Independent of linac, TPS and treatment delivery method
• Suitable for a plan from any clinical site e.g. H&N, prostate, breast
• Quick & simple as possible. Therefore:
  • Use existing patient plans.
  • Use commonly available equipment
• Should be effective for detecting problems with IMRT modelling / beam delivery. Therefore:
  • Absolute doses
  • Spatial dose distribution – 2D films of individual beams
• A single consistent method should be used for measurement and analysis
Pilot study – Feb/Mar 2009

• Aimed to develop a clear and unambiguous protocol and detect problems in advance
• Complex head and neck cases
• Ipswich (Varian machines, Eclipse TPS, dynamic delivery)
• Christie (Elekta machines, Pinnacle TPS, step and shoot delivery)
• Addenbrookes (Siemens machines, XiO TPS, step and shoot delivery)
• Showed that the proposed method was practical
Methods - Equipment

As simple a set up as possible so that equipment would be available at all centres:

- Solid water blocks
- Ion chamber and electrometer
- Alanine pellets – National Physical Laboratory
- Plate to hold alanine - Christie
- EDR2 film - Christie
Methods - preparation

- Choose IMRT plan
- Each beam recalculated on a square phantom – dose plane at 5cm deep, 95cm SSD
- Selected one field with a suitable place for point measurement (high dose, low dose-gradient)
- TPS point dose at 4 positions of alanine chips (coordinates from isocentre recorded)
- Dose plane exported from TPS and sent to Christie
Measurements – ion chamber (all beams)

• Measure standard output with centres own calibrated chamber and electrometer
• Move to position for dose point measurements
• Measure dose at this point to check set-up
• Position recorded with EPID or digital photo
Measurements – Alanine (one beam only)

• Perspex plate under 5cm solid water build up plus solid water backscatter (95cm SSD)
• IMRT beam delivered multiple times to give ~10 Gy to alanine chips
• Reference dose of 10Gy delivered to second set of 4 alanine chips at the centre of a 10x10cm field, set up as above
• Alanine pellets returned to NPL for analysis
Measurements - Film

- All films from same batch of Kodak EDR2
- Each field delivered to a film (5cm deep in solid water block, 95cm SSD, with backscatter)
- Calibration film
- All films returned to the Christie for developing and analysis
Analysis - Films

- Flatbed scanner
- Uniformity correction applied
- Analysed in PTW Verisoft 3.1
- Aligned & calibration applied
- Normalised to high dose, low dose-gradient point
- Calculate % of pixels passing the gamma test at 2%/2mm, 3%/3mm, 4%/4mm within the 20% isodose line.
- Two main analysers – cross checked against each other
- Strange results repeated
Results

• 57 centres participated (out of 62 centres in the UK)

• 78 plans: 35 Prostate, 32 H&N, 4 breast, 5 PPN, 2 others.

• 68 inverse planned, 10 forward planned
Tolerances

- 5% for alanine measurements
- 95% pixels passing gamma evaluation
  - local gamma
  - within 20% isodose
  - 20% of mean dose at normalisation points on all fields for a plan
    - 3% / 3mm for prostate/breast
    - 4% / 4mm for head and neck & other complex sites
Film results – prostates & simple sites

- Fluence maps at 3%/3mm
- All fields within 95% pixels passing
- Maximum percentage of failed pixels: 4.2%
Film results – H&N and complex sites

- Fluence maps at 4%/4mm
- 1 further beam is off-scale, in the 80-90% pass range.
- 8/245 (3.3%) out of tolerance
Alanine results – 10x10cm reference fields

- One measurement was off-scale: at +10.1%
- 1/67 (1.5% out of tolerance)
Alanine results – IMRT fields

- A further 3 measurements were off-scale: at:
  - -77.1%
  - -29.1%
  - -14%
  respectively.
- 4/78 (5.1% out of tolerance)

Mean difference 0.05%.
Standard deviation 1.5%
Results – ion chamber

- At alanine dose points
- Mean -0.1%
- SD 1.9%
- Cf -0.1±1.6% for alanine
- Excellent agreement
Practical problems

- TPS submission problems
  - Field of view too small, incompatible file format, etc.
  - All resolved on resubmission
- Calibration film
  - Maximum dose of 1Gy caused some profiles to plateau at 1 Gy for regions of higher dose
  - Artificially extended relevant calibration curves by deriving polynomial fit to data
- One envelope was damaged in the post
  - Resulted in a film being exposed to light and ruined
Conclusions

• Reassuring results - we’re doing quite well
• We should be doing well in this kind of audit
• Final mop-up round to repeat strange results
• Not worth repeating – any further audits should be different. E.g. in phantom from delivered gantry angles.
• Seems to be an appetite for further audits
• Further audits would need proper funding
Acknowledgements

- Geoff Budgell, Michael Trainer & Ellie Bradshaw, The Christie
- Peter Sharpe & team, NPL (alanine measurements)
- Peter Williams
- Hayley James (Ipswich) & Claire Hart (Addenbrookes) – pilot study
- Steve Bolton, IPEM Audit Group
- Rest of the steering committee: Simon Duane, Emma Wells, Richard Clements, Tom Jordan, Viv Cosgrove