Verification of Advanced Radiotherapy Techniques

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Background

- Dosimetry accuracy affects RT outcome
- Verify by undertaking QA of RT
- Audit gives an external independent assessment of the dosimetry and can help to identify possible improvements and occasionally find issues which need addressing immediately
- For complex RT: Benefit in combining the dosimetry experience from NPL and complex RT experience from NHS
Partnerships

- NCRI RT Trial QA Group
- IPEM RTSIG Interdepartmental Dosimetry Working Group
- UK SABR consortium
- Audits of advanced RT
National Intensity Modulated RT audit

- 2008 National RT Advisory Group concerned about slowness of IMRT uptake and accuracy in UK
- IPEM
  - RT SIG
  - Interdepartmental audit network
- Christie hospital – lead staff
- NPL – provided alanine service
- NCRI RT Trials QA Group
- AXrEM – provided funding for films
Aims of National IMRT audit

- Independent check on the efficient implementation of IMRT in the UK

- 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.
Aims of National IMRT audit

- 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.
National IMRT audit

- Mail based audit
  - Film and alanine dosimeters
- Measurements
  - Each individual field
- Ion chamber measurements
  - Made by each participating centre

Fig. 1. Perspex plate for holding alanine pellets set up for an IMRT measurement before placing the 5 cm water-equivalent material on top. A piece of graph paper has been placed under the Perspex plate for clarity and to assist set-up. On the right the central holder for the alanine pellets has been zoomed.
National IMRT audit

- 57 of 62 centres participated
- Film measurements:
  - All less complex IMRT plans passed
    - > 95% pixels passed 3%/3mm
  - 98.7% more complex IMRT plans
    - > 95% pixels passed 4%/4mm
- For alanine measurements:
  - 94.9% of the measurements differed by <5% from the TPS
A national dosimetric audit of IMRT

Geoff Budgell, Joe Berresford, Michael Trainer, Ellie Bradshaw, Peter Sharpe, Peter Williams

North Western Medical Physics, The Christie NHS Foundation Trust, Manchester, UK; National Physical Laboratory, Middlesex, UK
National IMRT audit

- Excellent take up
  - Simplicity of measurements
  - Free

- The audit shows that modelling and delivery of IMRT is accurate, suggesting that the implementation of IMRT has been carried out safely
National IMRT audit

‘It would be better to test other parameters not tested in the current audit. Examples of future audits could include the ability of the TPS to meet planning constraints, the delivery to an anthropomorphic phantom from the treatment gantry angles rather than to a flat phantom from a fixed gantry angle, and the inclusion of the new rotational forms of IMRT.’
National rotational IMRT audit (NRRA)

- Surveyed 62 UK cancer centres in 2010
- Around 30% were already treating with some form of rotational IMRT
- Volumetric Modulated Arc Therapy (Varian or Elekta VMAT) or Tomotherapy
- This rapid uptake led to the need for a national dosimetry audit for rotational IMRT
- NPL, RTTQA, IPEM, Royal Surrey County Hospital
NRRA: Methods

- Conventional audit methods are individual ionisation chamber point dose measurement, alanine, and film dosimetry - can be time consuming

- New methodology needed for rotational radiotherapy

- Various commercial detector arrays have become available, allowing for verification of absolute dose in a large number of positions with immediate results

- Can an array be used in an audit setting?
NRRA: Equipment

- PTW Octavius II/seven29 array
- Robust to transport
- Straight forward to calibrate
- Analysis results typical of systems used in visited hospitals
- Ability to compare with standard audit measurement approaches
NRRA: Equipment comparison

- PTW Semiflex ion chambers
- PTW 729 2D array
- Gafchromic film
- Alanine
NRRA: Methodology

Measurements were made in 35 centres with 44 systems. All were already treating or were ready to treat.

These included:

- 27 Varian (22 Eclipse, 3 OMP, 2 Pinnacle TPS)
- 11 Elekta (6 Monaco, 3 OMP, 2 Pinnacle TPS)
- 6 Helical Tomotherapy
NRRA: Planning requirements

- Generic plan: 3DTPS
- UK clinical trial portfolio plan
  - Prostate and pelvic nodes
  - Head and Neck
  - Breast
- Enabled credentialing for that trial

Tsang et al. Br J Radiol. 2013 Feb;86(1022)
NRRA: Analysis

- PTW Verisoft software
- Gamma index (γ) calculations
  - Combination of dose difference and distance to agreement
- Point dose differences
  - PTVs and OARs
NRRA: Results

- 3DTPS test
  - 95% of the measurements differed by <4% from the TPS
  - 89% of planes had more than 95% of points passing gamma criteria of 3%/3mm

- Clinical plans
  - 95% of the measurements differed by <3.2% from the TPS
  - 99% of planes had more than 95% of points passing gamma criteria of 3%/3mm
NRRA: Issues identified

- Couch modelling needed
- Minimum leaf gap too small
- High modulation / high MUs
- Non-continuously variable dose rate
- Lack of information as to what some TPS/Linac combinations are capable of achieving
- Centre buddies
- Lasers and barometers
NRRA: Conclusions

• A national dosimetry audit of rotational radiotherapy has been undertaken

• More than 93% of analysed planes achieved more than 95% pass rates for gamma parameters of 3%/3mm

• The majority of centres achieved accurate implementation of TPS modelling and delivery for VMAT and Tomotherapy
NRRA: Future

- Evaluation of the standards which others starting a VMAT program could achieve and help to set future verification tolerances

- Methodology adopted by Australasian Clinical Trials Group (TROG)
  - Audit currently underway

- Considered by EORTC and Dutch IMRT audit group
UK SABR Lung dosimetry audit

- Designed to assess the positional and dosimetric accuracy of a SABR lung treatment delivery
- Achieved with the use of Alanine pellets and EBT3 GafChromic film dosimetry, placed in a CIRS lung phantom.
- Collaboration with UK SABR consortium, RTTQA, RSCH and Clatterbridge Cancer Centre
UK SABR audit

- Plan created on scan of the phantom
- Local planning and delivery technique used
UK SABR audit: Equipment

Farmer shaped insert pre-loaded with alanine pellets

Control

Stem

5mm

2.5mm
UK SABR audit

- 20 centres
- Running from October 2013
- Alanine from NPL
- Film from Clatterbridge Cancer Centre
- Coordinated by Royal Surrey County Hospital

- European Metrology Research Project (EMRP)
  - Pilot European Audit
  - UK, Holland and Denmark
National HDR Brachytherapy audit

- Develop a comprehensive brachy audit methodology
  - Accurate measurement of source strength / dose to a point
  - Perform a ‘system audit’ of intended and delivered dose distributions around clinical applicators
- Bring brachytherapy audit in line with external beam audit
- Provide QA process for the INTERLACE clinical trial brachytherapy component
- Collaboration between NPL, IPEM and RTTQA
National HDR Brachytherapy audit

- ‘INTERLACE’ trial alanine phantom
National HDR Brachytherapy audit

- End-to-end (system) phantom
  - ‘BRAD’ (brachytherapy applicator dosimetry)
Design and implementation of a film dosimetry audit tool for comparison of planned and delivered dose distributions in high dose rate (HDR) brachytherapy

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National HDR Brachytherapy audit

- Audit methodology developed for comprehensive QA assessment of HDR/PDR brachytherapy dosimetry using alanine and film dosimetry phantoms
- Pilot audits with alanine and film phantoms completed
- Monte Carlo work to be completed for alanine phantom
- Full UK audit programme from September 2013 into early 2014
Conclusions

- Advanced audit need multidisciplinary input
  - Expertise in different areas from different groups
- Collaboration with several other audit groups
- Results from UK audits have been excellent
- Audit has helped to
  - Support implementation
  - Identify issues
  - Set standards
Future

- More advanced techniques
- More end-to-end audit
- Development of appropriate anthropomorphic phantoms
  - Ability of treatment planning systems to model dose in heterogeneous tissue
- Partners
  - RTTQA
  - IPEM
  - SABR consortium
  - ACDS and TROG