Introduction of RapidArc™: an example of commissioning and implementing a QA programme for a new technology

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What is RapidArc (or VMAT) ?

• An isocentric treatment in which the dose rate, gantry speed, and MLC leaf positions are all changing

• Treatment carried out in a single rotation
  – Two rotations may improve distribution

• Substantially reduced treatment time
Step One

• Establish a multidisciplinary team
  – Doctors
  – Physicists
  – Radiation Technologists
The Team

• Clinical Oncologist
  – Isabel Syndikus

• Physicists
  – Helen Mayles, Richard Clements, Julie Kirk, Simon Temple, Stephen Riley

• Radiation Technologists
  – Ruth Clements, Angela Heaton

• Their contributions to this talk are gratefully acknowledged
Tasks for the Team

• Requirements for the treatment machine to deliver VMAT accurately
• Quality control procedures
• Planning system parameters that may need to be known more accurately
• Phantom measurements to verify achievable accuracy
• Requirements and methodology for ongoing quality assurance of patient treatment plans
• Patient setup and verification
How does it work?

- MLC leaf positions are linked to the gantry rotation angle
- Gantry rotation is linked to dose delivered
- Control points have a cumulative dose value, MLC leaf positions and gantry angle
- Machine calculates gantry speed and dose rate
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What can go wrong

• MLC leaf speed
• Gantry speed
• Dose rate control
• MLC leaf calibration
Machine Tests

Following Ling et al
IJROBP 72 575-581 2008
Variable Leaf Speed Test

- 4 dynamic segments (From Right to Left)
  - Field width 30 mm
  - 4.6 mm/s  138 MU/min
  - 9.2 mm/s  277 MU/min
  - 18.4 mm/s  554 MU/min
  - Field width 45 mm
  - 27.6 mm/s  554 MU/min
Dose Rate Test

• 7 segments
  – 111 MU/min for 90°
  – 222 MU/min for 45°
  – 332 MU/min for 30°
  – 443 MU/min for 22.5°
  – 554 MU/min for 18°
  – 600 MU/min for 15° at 5°/s
  – 600 MU/min for 12.9° at 4.3°/s

• Equivalent to 0.33, 0.67, 1.0, 1.33, 1.67, 2 and 2.33 MU/°
Comparative Patient Plans

• Aim to demonstrate that RapidArc produces plans that are better or at least equally good
• Consider different sites one by one
Prostate Simultaneous Boost

Rapid Arc

IMRT
Prostate Simultaneous Boost

- Prostate + Seminal Vesicles
- Rectum
- Bowel
- Bladder
- Femoral Heads

- RapidArc
- IMRT
Prostate and Pelvic nodes

Rapid Arc

IMRT
Individual Patient QA

• Many current systems just allow one beam to be analysed

• We need to look at the composite beam in 3D
  – Delta4 has been specially adapted for RapidArc including gantry angle monitoring
Delta4 3D Diode Phantom
Effect of couch correction
Effect of couch correction
Individual Patient QA

• Many current systems just allow one beam to be analysed
• We need to look at the composite beam in 3D
  – Delta4 has been specially adapted for RapidArc including gantry angle monitoring
  – We have also mounted it on a carriage that allows us to observe the effect of breathing
Delta4 Mounted on a Moving Carriage to Simulate Respiration
Individual Patient QA

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• We need to look at the composite beam in 3D
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  – We have also mounted it on a carriage that allows us to observe the effect of breathing
• For absolute dose measurements it is useful to have a patient shaped phantom
Water Phantoms for QA
Individual Patient QA

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- For absolute dose measurements it is useful to have a patient shaped phantom
- It is also important to check reproducibility of delivery
Repeatability
Individual Patient QA

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• We need to look at the composite beam in 3D
  – Delta4 has been specially adapted for RapidArc including gantry angle monitoring
  – We have also mounted it on a carriage that allows us to observe the effect of breathing
• For absolute dose measurements it is useful to have a patient shaped phantom
• It is also important to check reproducibility of delivery
• For some patients geometric accuracy is a key factor
Multiple Brain Metastases
Conclusions

• New techniques need new approaches to QA
• Assessment of the risks can highlight those areas that need to be assessed
• A well documented process should be followed with independent review
• Machine QA should be ongoing
• The benefits of RapidArc appear to outweigh the potential risks