Image quality of on-board cone-beam CT acquired during VMAT delivery

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Conflict of interest statement

- T Marchant: None
- C Rowbottom: None
- C Moore: None
CBCT during VMAT?

Rotational delivery raises possibility to acquire CBCT concurrently with treatment

- More representative of treated anatomy than pre or post treatment image
- Time saving

BUT

- Potential effects on image quality:
  - Increased x-ray scatter from MV treatment beam
  - Uneven spacing of projection images
Study outline

• Preliminary study to investigate image quality

• CBCT of Rando phantom acquired simultaneously with VMAT delivery (Elekta Synergy*)

• 8MV Prostate VMAT plan (57Gy / 19#), single rotation, 46 Control Points, 517MU, 2.3 mins

• Imaging parameters 120kV, 750 frames, 40mA, 16ms per frame, M20 collimator, Bow-tie filter, 11.5 mGy

• Standard CBCT acquired for comparison, same settings, 650 frames

• Also applied “shading” correction algorithm to CBCT images†

*Simultaneous kV and MV not approved for clinical use yet
†Marchant et al 2008 Phys Med Biol 53 p5719
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Noise

Standard deviation, averaged over seven uniform regions throughout phantom

- Increased noise in VMAT image
- Shading correction has little effect
Uniformity

Maximum percentage difference between any two of the ROIs

- Both CBCTs much poorer uniformity than ref CT
- Uniformity degraded in VMAT CBCT image
- Shading correction improves CBCT uniformity
CNR

Lower density region in phantom used to define contrast to noise ratio

\[ CNR = \frac{Tissue_{\text{mean}} - Bone_{\text{mean}}}{Tissue_{\text{SD}}} \]

- Ref CT has best CNR
- CBCT during VMAT has lower CNR than standard CBCT
- Shading correction has little effect
HU accuracy

Maximum percentage difference between any CBCT ROI and corresponding CT ROI

- Both CBCTs have poor HU accuracy
- CBCT during VMAT has degraded HU accuracy
- Shading correction improves HU accuracy to ~1%

*XVI scatter correction switched off
Summary

• CBCT images acquired during VMAT have lower quality than standard CBCT

• Increased noise, decreased CNR, decreased uniformity and increased streak artefacts

• Shading correction algorithm for CBCT improved uniformity and HU accuracy for VMAT and standard images

Further work

• Investigate why other authors found no effect on image quality
  – Probably due to kV imaging dose used (relative to MV scatter)
  – Clinical usefulness of beam-on images