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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

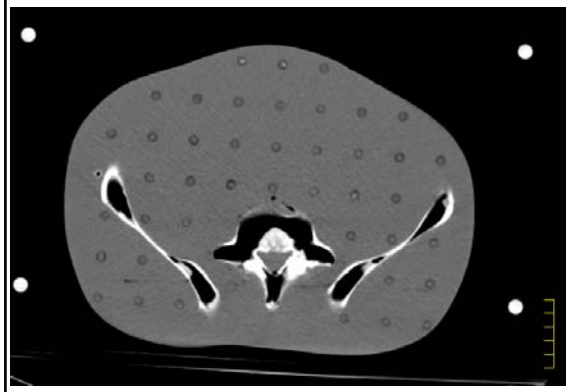
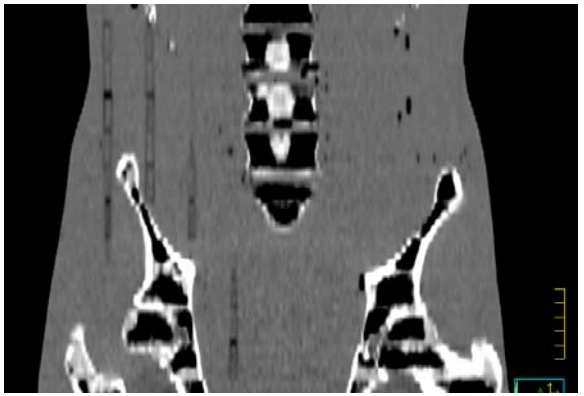
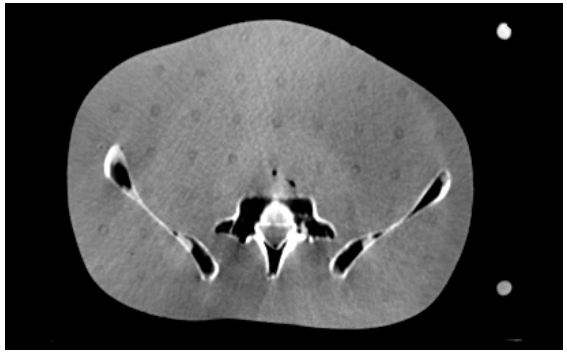
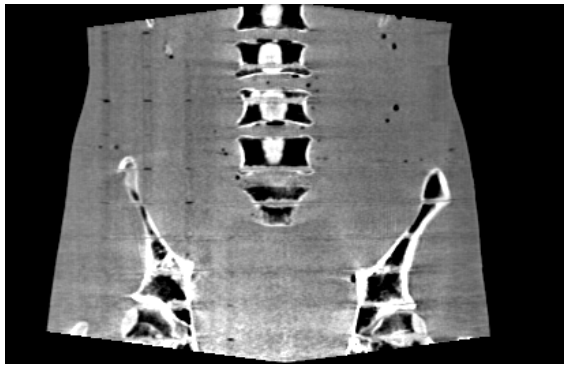
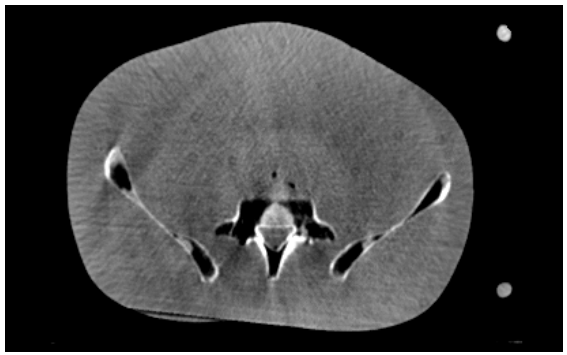
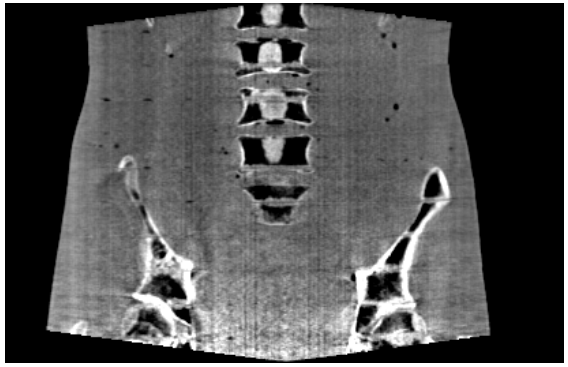
- Potential effects on image quality:
  - Increased x-ray scatter from MV treatment beam
  - Uneven spacing of projection images

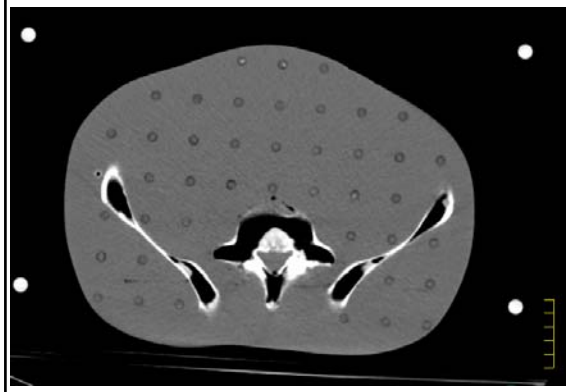
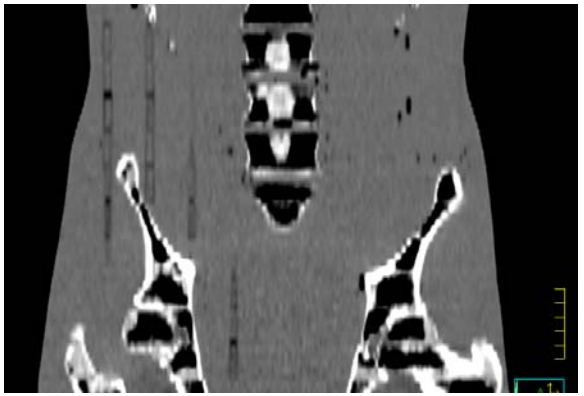
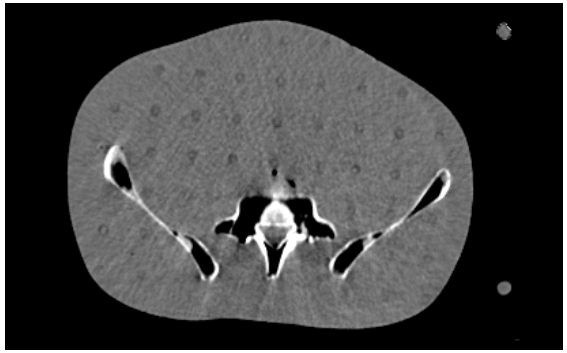
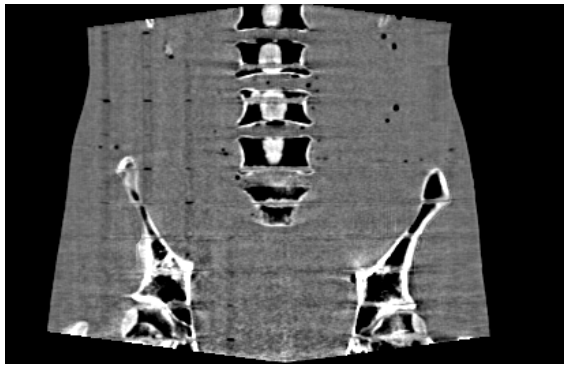
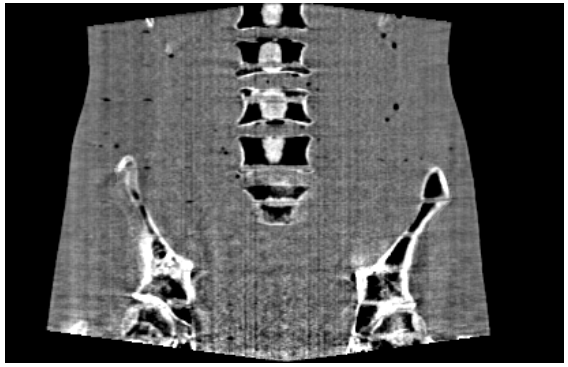
Study outline

- 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[†]

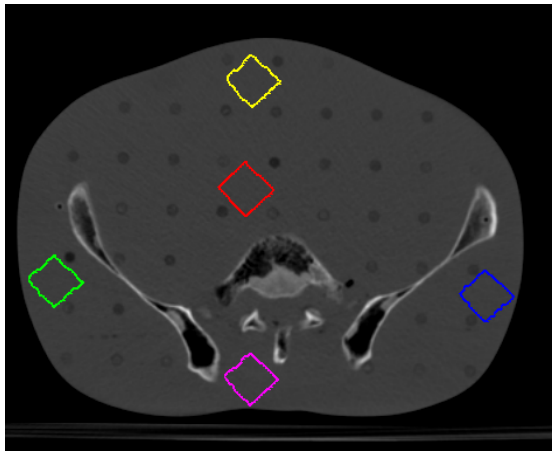
*Simultaneous kV and MV not approved for clinical use yet

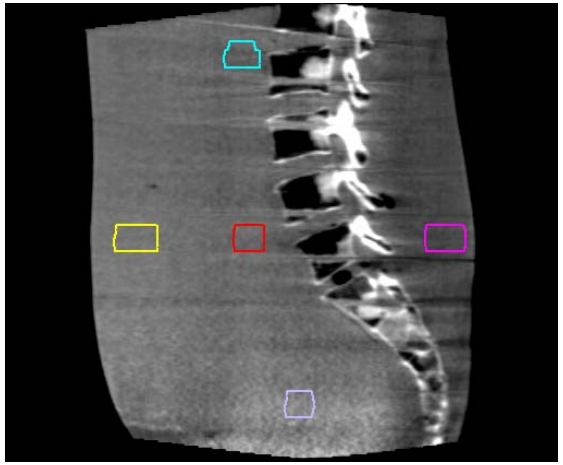
[†] Marchant et al 2008 Phys Med Biol **53** p5719

	Axial	Coronal
CT		
CBCT kV only 650 proj 10 mGy		
CBCT during VMAT 750 proj 11.5 mGy		

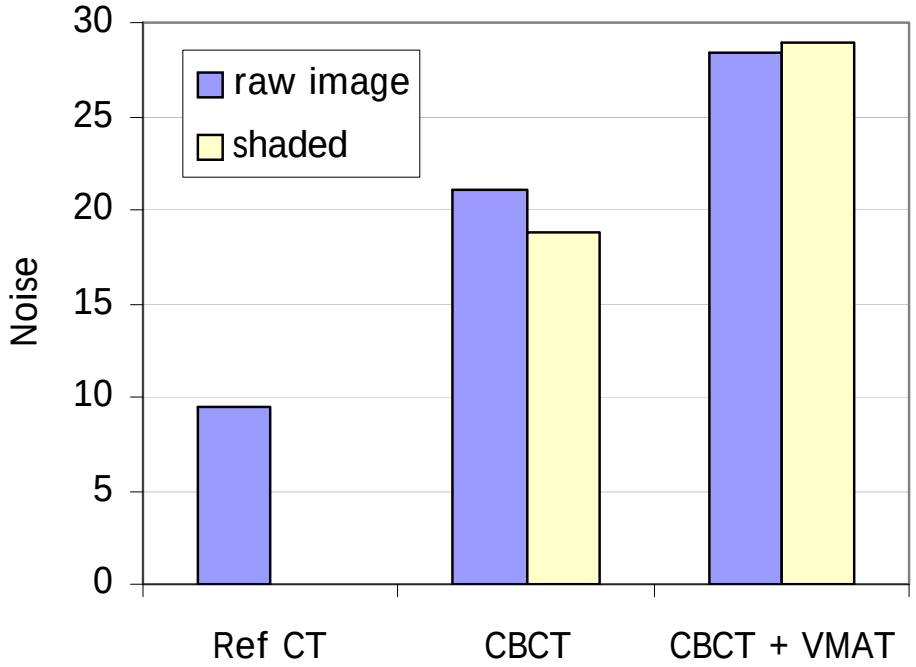
	Axial	Coronal
CT		
CBCT kV only 650 proj 10 mGy **With shading correction**		
CBCT during VMAT 750 proj 11.5 mGy **With shading correction**		

Noise





Standard deviation, averaged over seven uniform regions throughout phantom



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

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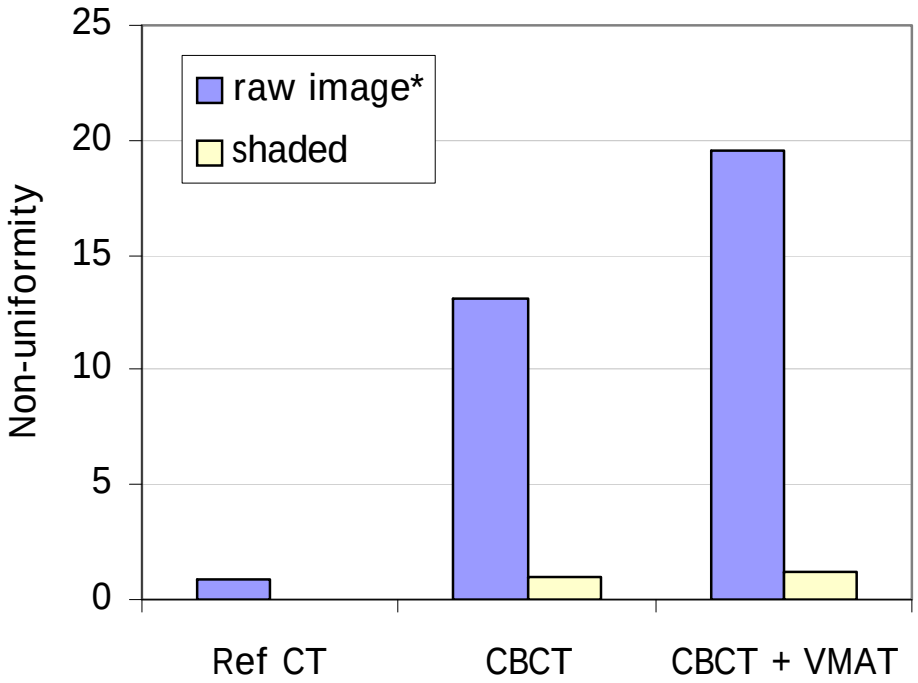
Uniformity

Maximum percentage difference between any two of the ROIs



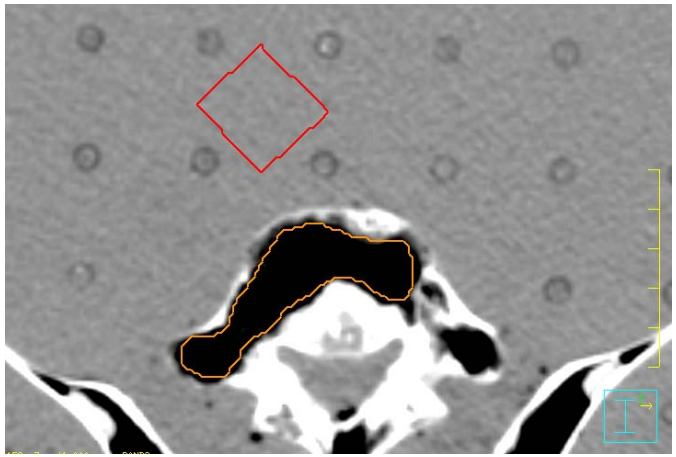
*XVI scatter correction switched off

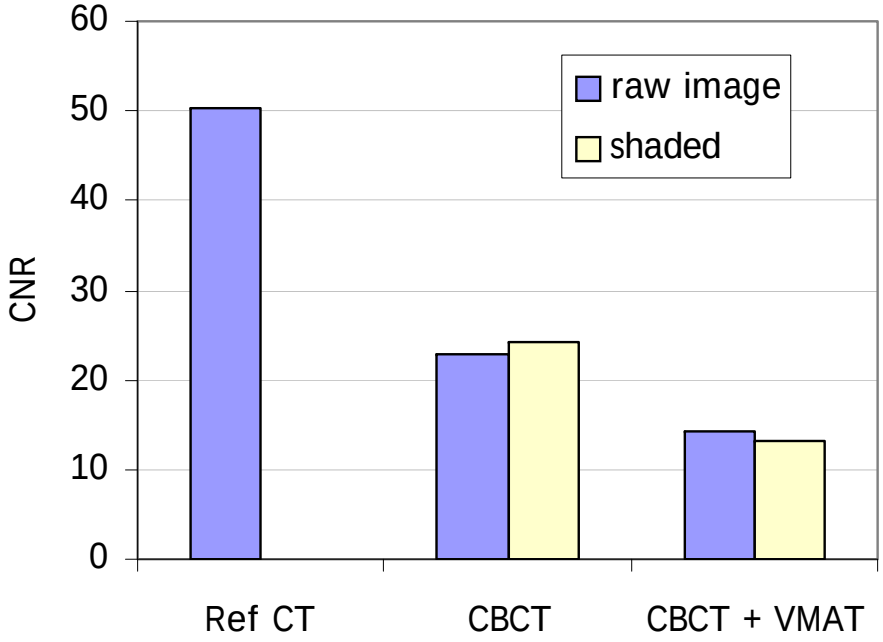
- Both CBCTs much poorer uniformity than ref CT
- Uniformity degraded in VMAT CBCT image
- Shading correction improves CBCT uniformity

CNR

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

$$CNR = \frac{Tissue_{mean} - Bone_{mean}}{Tissue_{SD}}$$

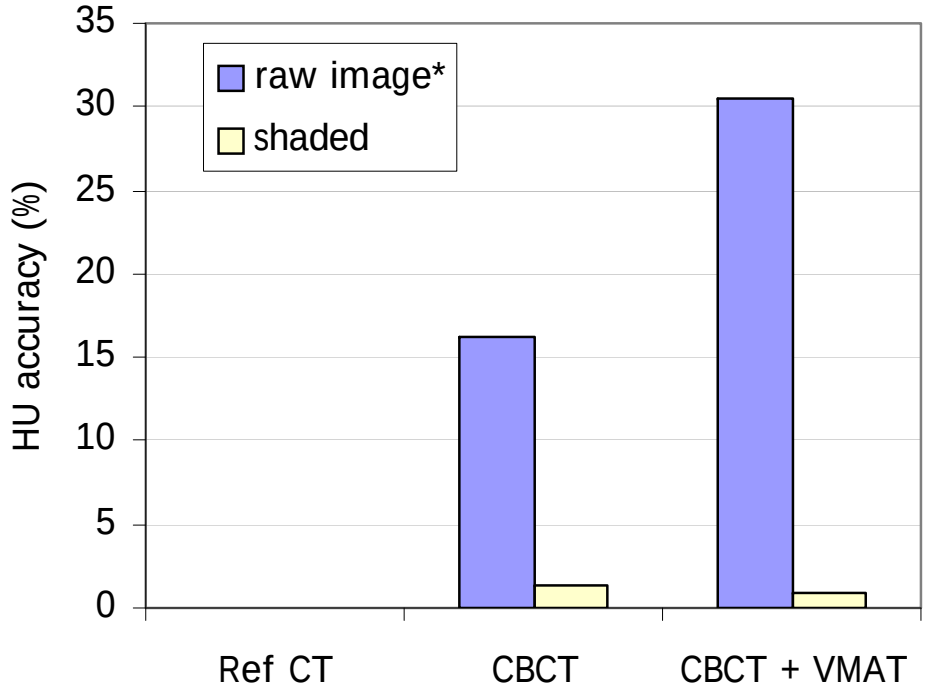




- Ref CT has best CNR
- CBCT during VMAT has lower CNR than standard CBCT
- Shading correction has little effect

HU accuracy

Maximum percentage difference between any CBCT ROI and corresponding CT ROI



*XVI scatter correction switched off

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

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