Nationellt möte för sjukhusfysik
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Evaluation of a metal artefact reduction algorithm in CT-studies used for radiotherapy treatment planning

Master of Science Thesis 2012

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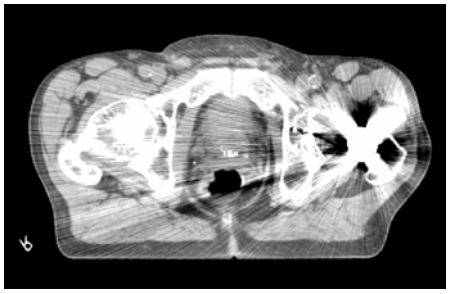
Stockholms universitet

AKADEMISKA SJUKHUSET

Purpose

- Evaluation of a metal artefact reduction algorithm installed on a Philips Brilliance Big Bore CT at the radiotherapy department in Uppsala; *O-MAR*
  Metal Artefact Reduction for Orthopedic Implants

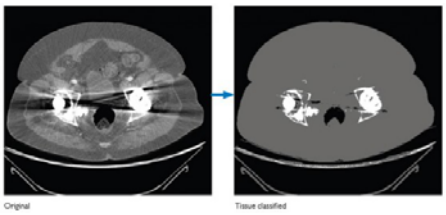
- Metallic objects like dental fillings, orthopedic prostheses and surgical implants cause severe artefacts in CT-images

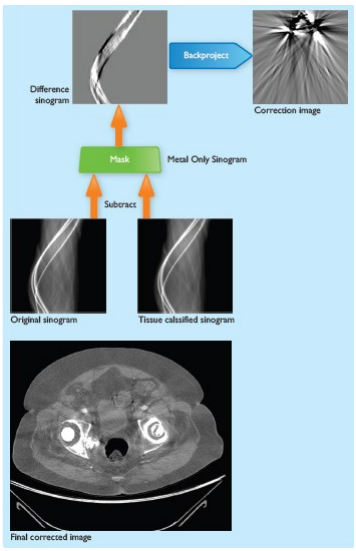


- Evaluation mainly for proton therapy

Background

- Iterative loop where the output is a correction image that is subtracted from the original input image
- Classification tissue/non-tissue
  → "Tissue classified sinogram"
- Backprojection of difference sinogram
  → Correction image



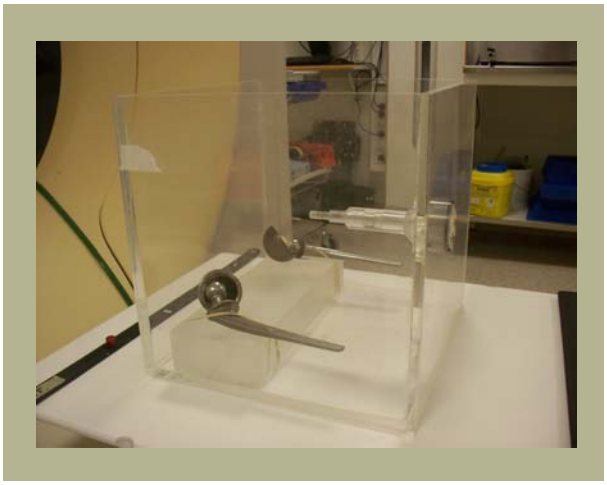


O-MAR, Philips Healthcare; 2011

Phantom measurements

Hip prostheses

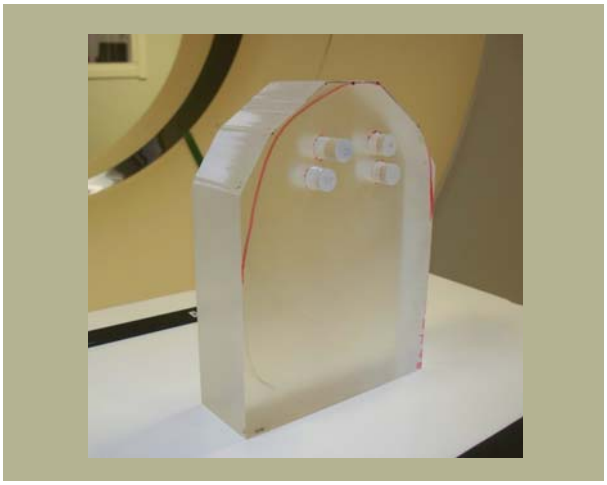
- Water phantom
- CT-images with one and two prostheses
- Reference images without any metal
- Comparison based on HU-statistics and dose calculations



Phantom measurements

Dental fillings

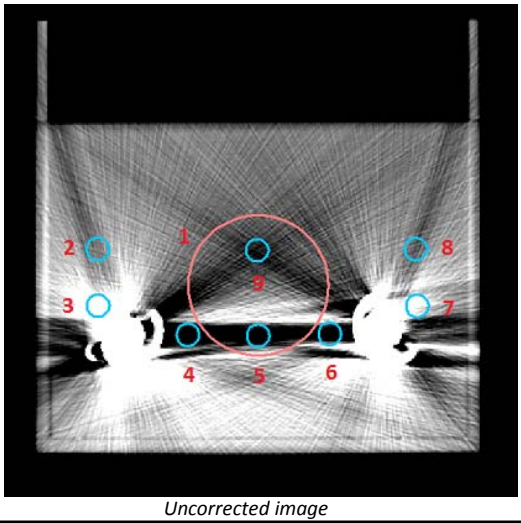
- PMMA with four fillings made of Rose's metal



Method

Evaluation of HU-values

- Comparison of the mean and standard deviation of HU-values in ROIs in the three image sets

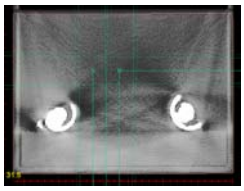


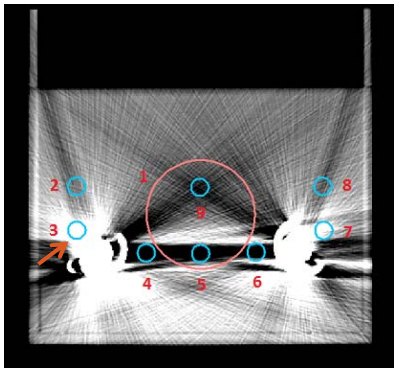
Uncorrected image

Results

Evaluation of HU-values

O-MAR: Mean HU-values closer to reference values and reduced standard deviations



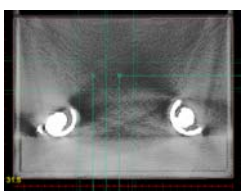


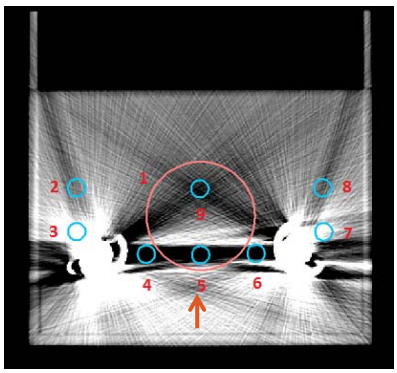
ROI no.	O-MAR		Uncorrected		Reference	
	Mean [HU]	SD [HU]	Mean [HU]	SD [HU]	Mean [HU]	SD [HU]
→ 3	119	31	500	137	4.8	12
5	20	27	-451	160	0.7	14

Results

Evaluation of HU-values

O-MAR: Mean HU-values closer to reference values and reduced standard deviations





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Results

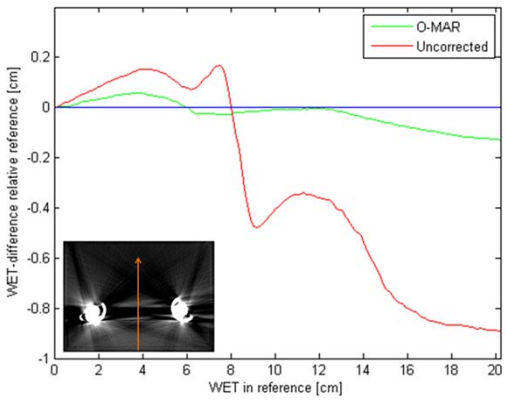
Evaluation of HU-values

WET – Water equivalent thickness

$$\mathrm{WET} = t_w = t_m \frac{\rho_m \cdot s_m/\rho}{\rho_w \cdot s_w/\rho}$$

ρ_w, ρ_m - mass densities of water and the medium

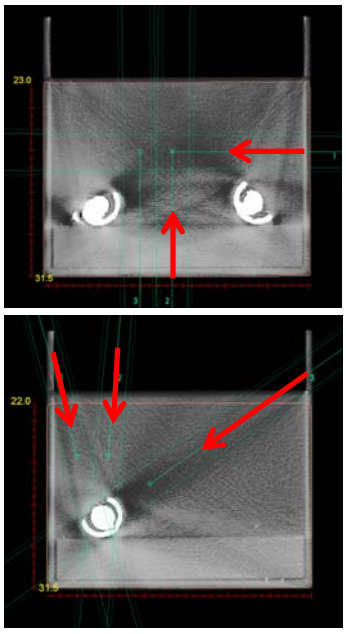
s_w/ρ, s_m/ρ - mass stopping power of water and the medium



Method

Proton dose calculations

- 130 MeV and 180 MeV proton fields applied to the phantoms
- Further adjustment of entrance energy of protons by additional range compensating filters
- Comparison of proton ranges (the distance to the distal 80% point of the peak)



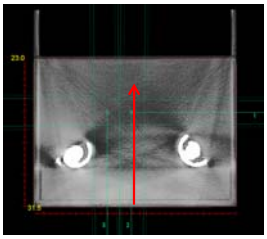
O-MAR images

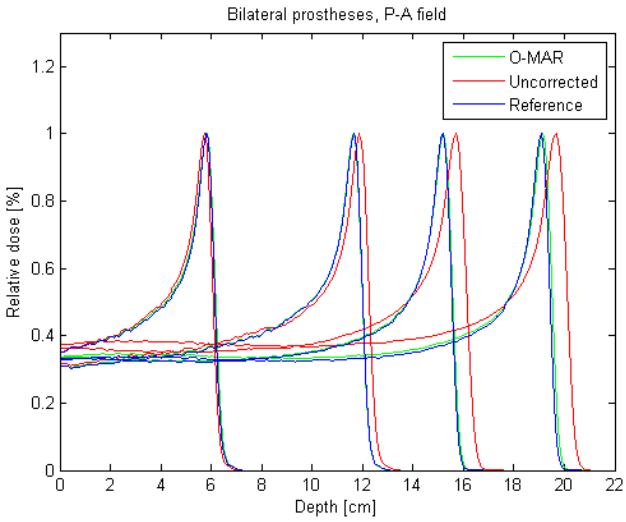
Results

Proton dose calculations

O-MAR:

Significantly decreases the proton range differences



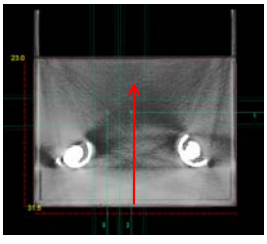


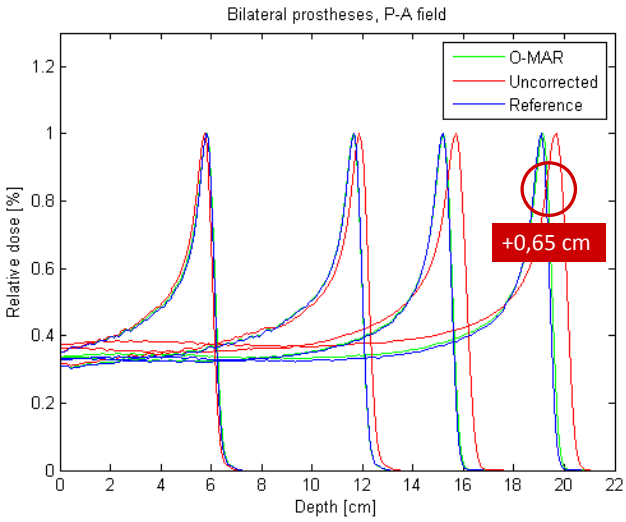
Results

Proton dose calculations

O-MAR:

Significantly decreases the proton range differences





Results

Proton dose calculations

O-MAR:

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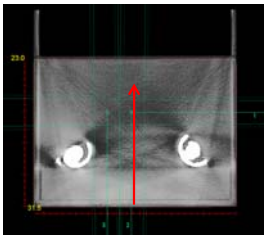
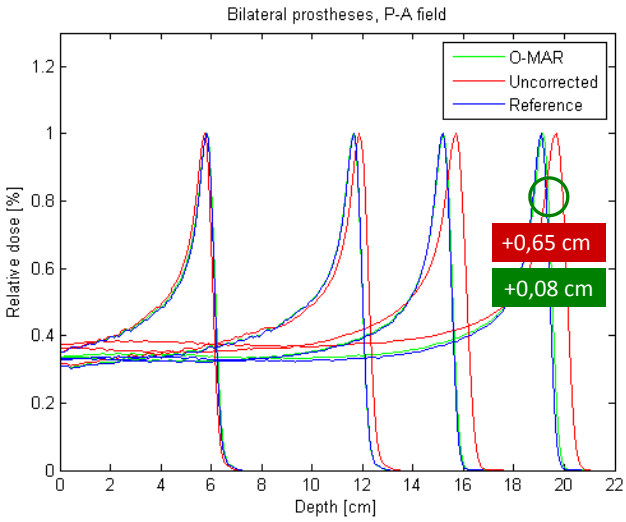




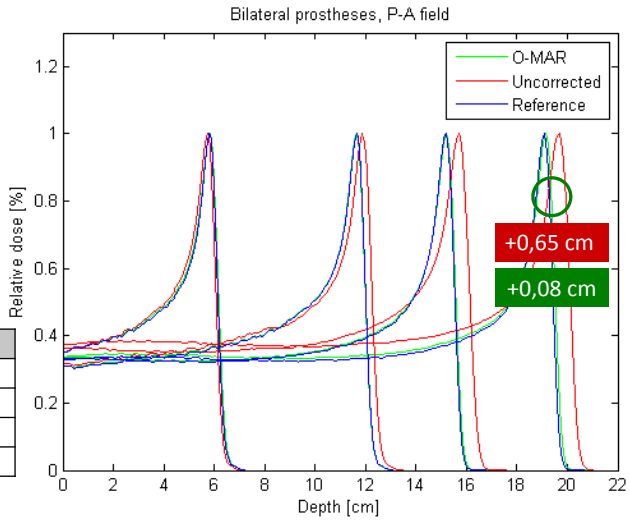
Results

Proton dose calculations

O-MAR:

Significantly decreases the proton range differences

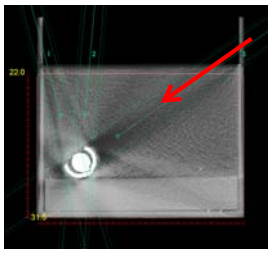
r_{ref} [cm]	Δr_{OMAR} [cm]	Δr_{uncorr} [cm]
6.02	0.02	-0.07
11.85	-0.01	0.25
15.40	0.03	0.55
19.30	0.08	0.65

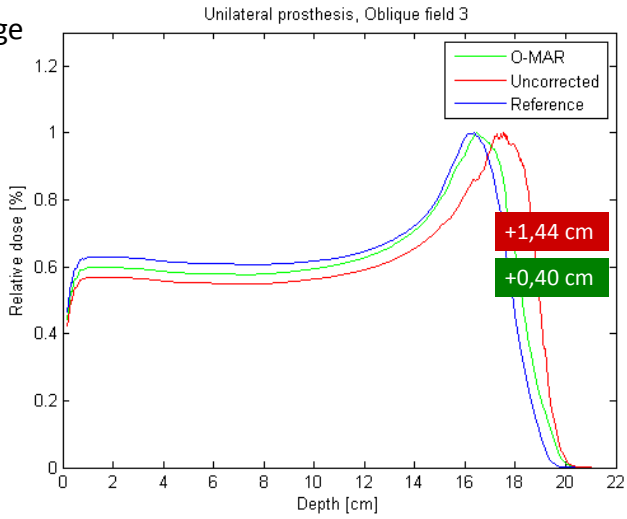


Results

Proton dose calculations

- Largest proton range differences seen for oblique fields applied along streaks

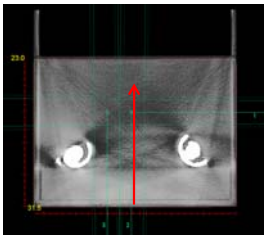


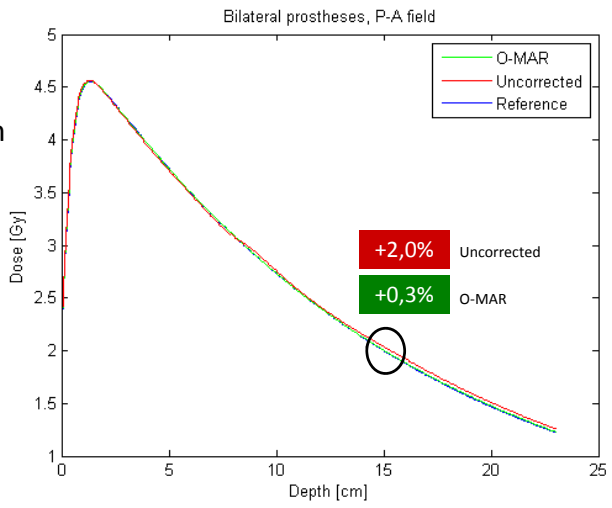


Results

X-ray dose calculations

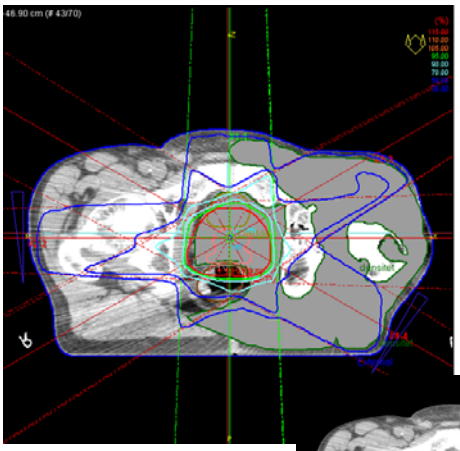
- 6 MV X-ray field applied to the bilateral hip prostheses phantom





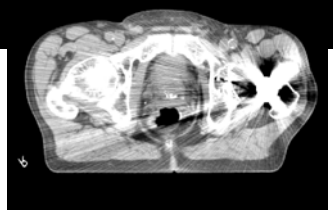
Results

X-ray dose calculations

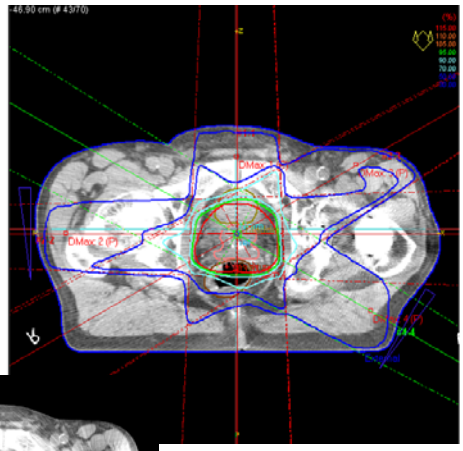


Redefined image

Mean dose to PTV: 2,03 Gy



Uncorrected image **2,02 Gy**



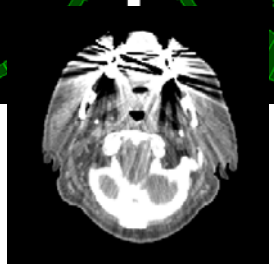
O-MAR image **2,01 Gy**

Results

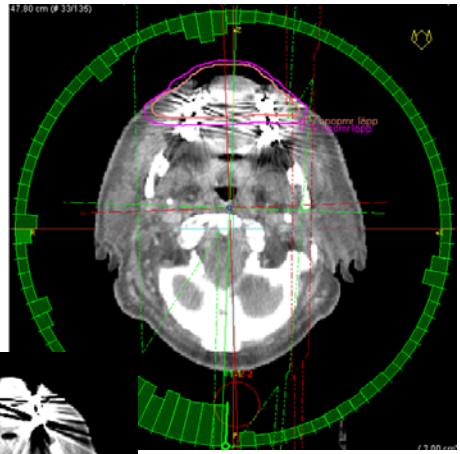
X-ray dose calculations

Redefined image

Mean dose to PTV: 2,05 Gy



Uncorrected image **2,05 Gy**



O-MAR image **2,05 Gy**

Conclusions

- O-MAR was shown to significantly improve the accuracy in proton dose calculations
- Proton fields along streaks should be used with caution
- O-MAR also reduced the dose differences in photon dose calculations, but no difference seen in patient cases