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REGION H

Artefact quantification of liquid and solid fiducial marker in single and dual energy CT with MAR

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Purpose

The aim of this study was to evaluate artefacts of liquid and solid fiducial markers for radiotherapy. Specifically in single energy CT (SECT) and dual energy CT (DECT) with different metal artefact reduction (MAR) algorithms on a clinical CT-scanner. The artefacts were quantified by severity and streaking Index (SI) on SECT and DECT with eight different MAR algorithms and with no MAR.

Conclusion

We quantified the SI and artefact severity for a series of both liquid and solid fiducial markers implanted in a simulated tumour in a thorax phantom. We showed that the MAR algorithms reduced both the SI and the artefact severity in both SECT and DECT for all markers but was better on the larger liquid markers (100-400 µL) and the markers with pure gold (Gold Anchor and gold marker). Additional evaluation of the artefact reductions effect on dose distribution in both photon and proton planning is needed.

Material and Methods

A total of 16 markers were evaluated, two liquid markers (BioXmark and Lipiodol) with varying volumes (10 to 400 µL) and five solid markers (PolyMark, BeamMarks, FusionCoil, Gold Anchor and a solid gold marker). Each marker was moulded into gelatine in a hollow low density polyethylene rod container with a diameter of 2.5 cm. Imaging was performed with the filled rod container placed inside a CIRS IMRT thorax phantom to represent a lung tumour with a fiducial marker inserted.

SECT and DECT-images were acquired for each marker inside their respective container inside the thorax phantom, additionally SECT and DECT images were acquired with gelatine filled container but with no marker to serve as a background. SECT images were acquired at 120 kVp, DECT-images were acquired at 80 kV and 140 kV, and further combined to represent a mono-energetic image at 70 keV. Tube current was selected so that both the SECT and the DECT scans would result in the same dose to the phantom, Slice thickness was 2 mm. A total of eight MAR reconstruction algorithms and one reconstruction without MAR were evaluated for both SECT and DECT. The software used on the CT scanner was a clinical evaluation version with the MAR functionality installed.

Results

For the liquid markers, the artefact analysis showed that the SI increased as a function of marker size (volume) in the absence of MAR. The reduction of the SI for the BioXmark worked best for the larger markers (100 to 400 µL) (Table 1, Figure 1). The SI was highest for the two gold markers when no MAR algorithm was used. The MAR algorithm reduces the SI most when the 'neuro' MAR algorithm was used for both SECT and DECT (Table 1).

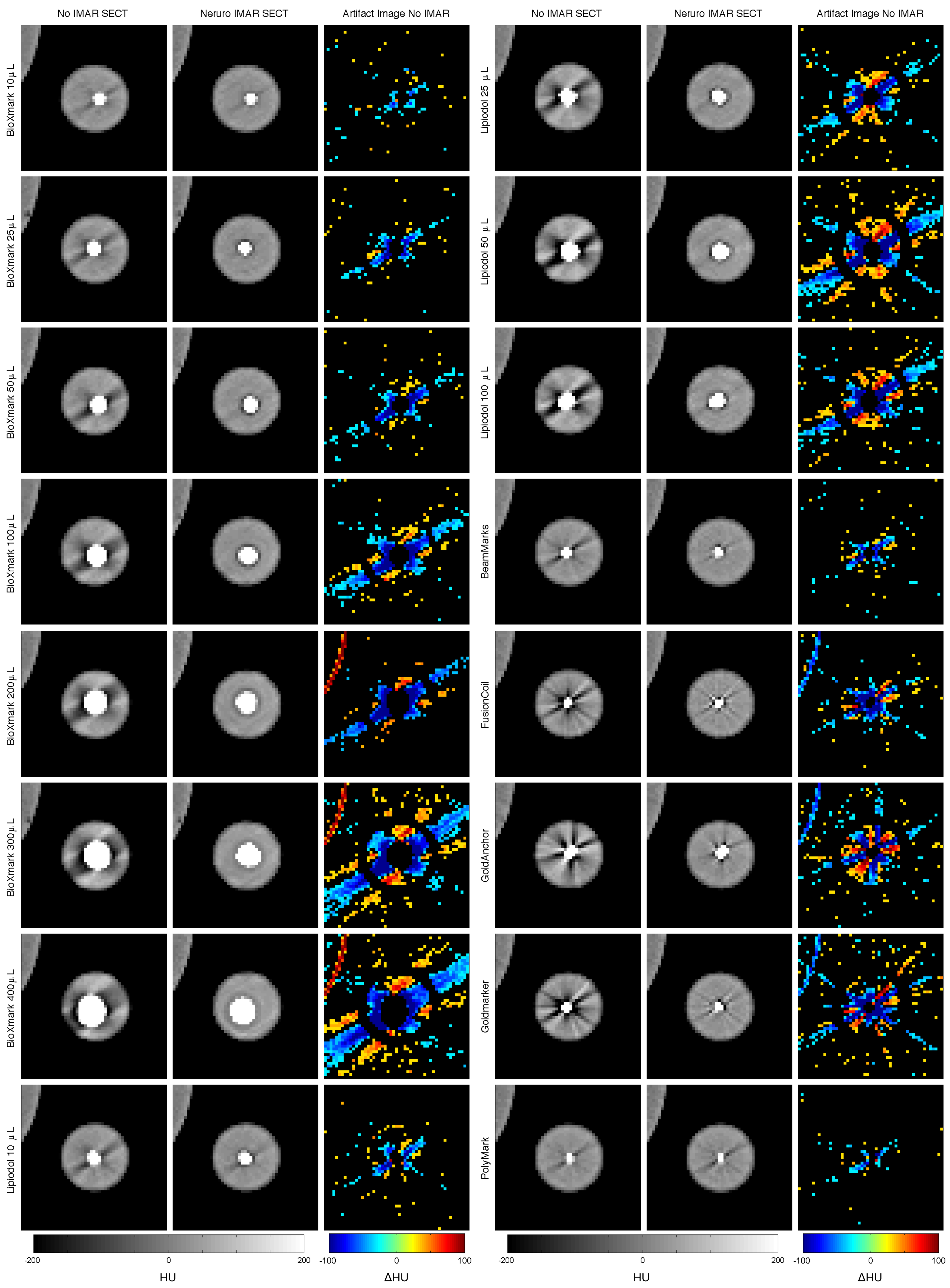

Figure 1. Column 1 and 4: Single Energy CT (SECT) images, no IMAR. Column 2 and 5: SECT with neuro MAR kernel. Column 3 and 6: artefact image, noise and marker removed.

Table 1. Streaking index (SI) and # pixels left SECT scans with & without the MAR neuro algorithm.

Marker	SI for SECT, no MAR	SI for SECT, MAR neuro	# pixels left SECT, no MAR	# pixels left SECT, MAR neuro	# pixels, marker in image	Mean HU marker on SECT
BioXmark 10 µL	10.79	8.89	72	50	16	699
BioXmark 25 µL	15.09	13.38	116	38	25	1186
BioXmark 50 µL	17.26	13.34	151	56	31	1477
BioXmark 100 µL	19.66	10.24	267	84	44	2028
BioXmark 200 µL	20.14	7.30	193	126	64	1925
BioXmark 300 µL	34.18	9.18	358	133	72	2698
BioXmark 400 µL	28.45	8.43	346	143	92	2597
Lipiodol 10 µL	15.47	12.57	126	72	19	1182
Lipiodol 25 µL	34.14	12.60	260	68	29	2043
Lipiodol 50 µL	38.16	14.23	348	50	39	3175
Lipiodol 100 µL	34.39	12.99	291	46	38	2054
BeamMarks	18.14	14.58	105	44	12	1529
FusionCoil	33.80	27.87	176	96	9	6138
Gold Anchor	62.36	24.20	262	85	18	2411
Gold marker	48.20	27.47	231	107	12	5645
PolyMark	16.23	14.55	55	65	9	918

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