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Comparison of Two Conceptually Different Classes of Metal Artifact Reduction (MAR) Algorithms for Clinical CT

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Introduction

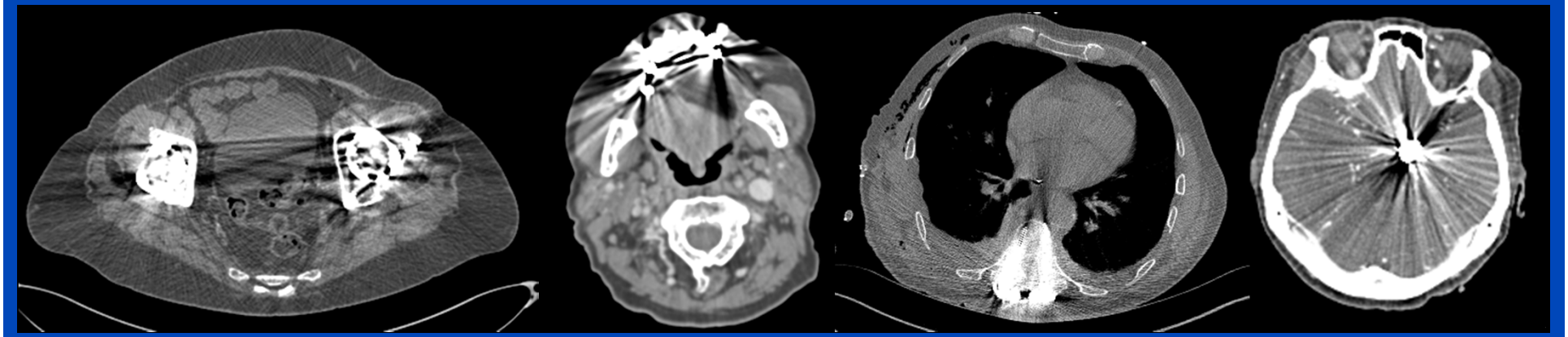
Aim:
To compare two algorithms for metal artifact reduction (MAR) in CT with respect to…

- the concept
- and the reduction of artifacts.

Metal Artifacts:

- Noise
- Beam hardening
- Scatter
- Nonlinear partial volume effect

Hip prosthesis | Dental fillings | Spine fixations | Coils



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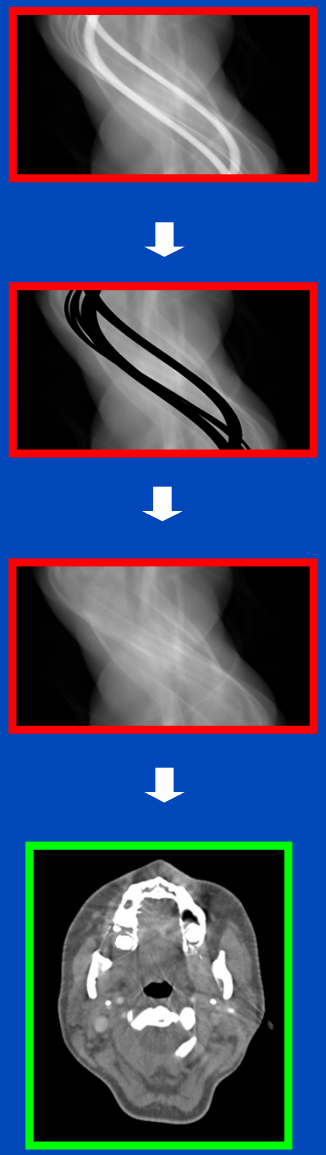
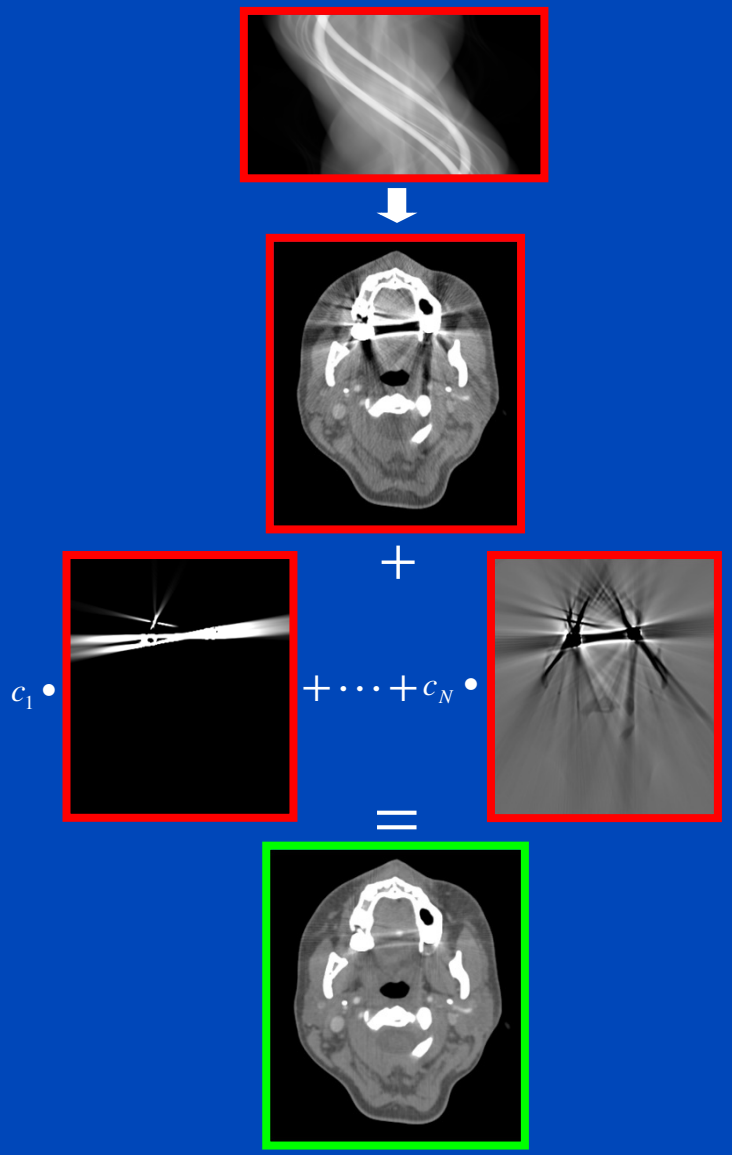
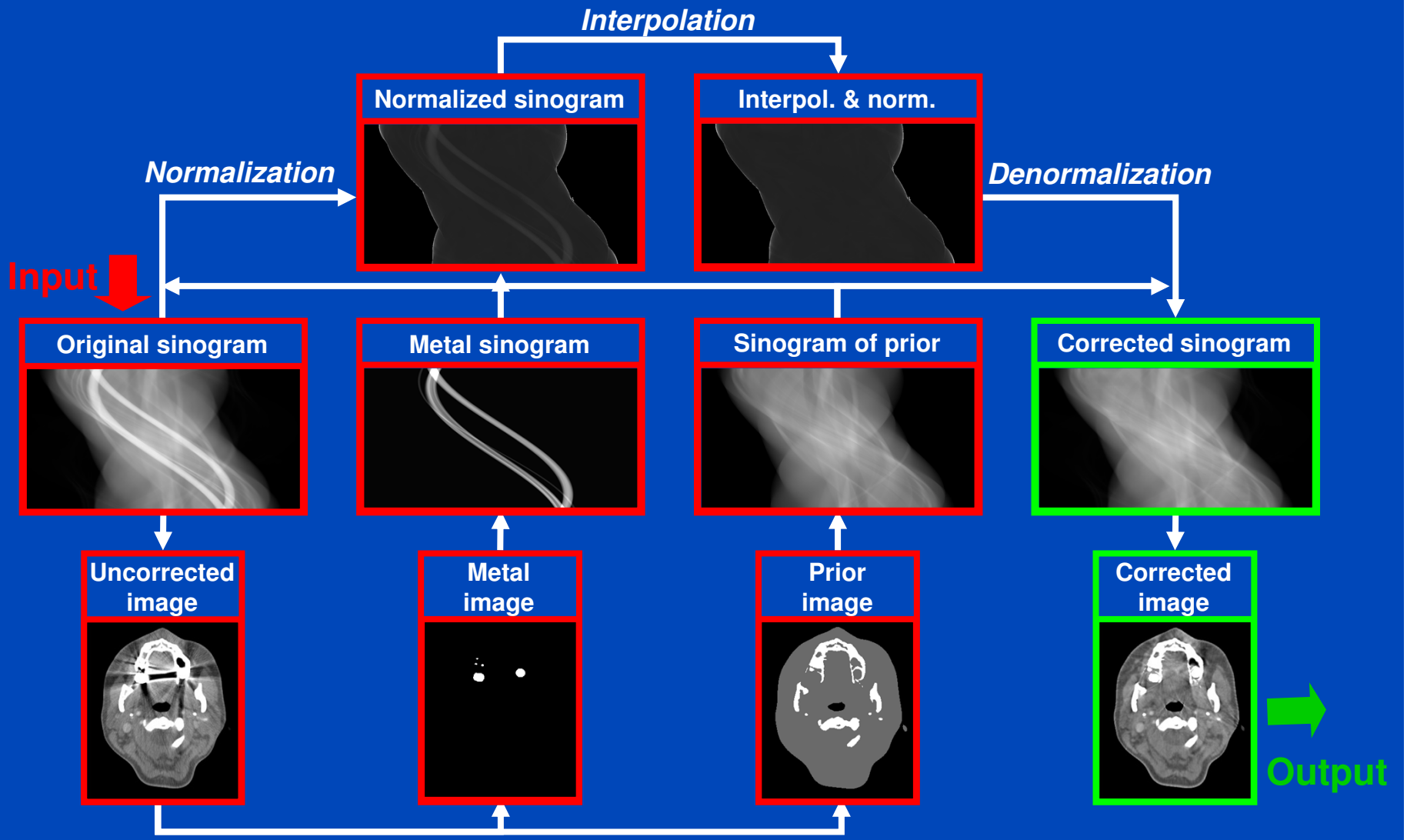
Replacement



Correction



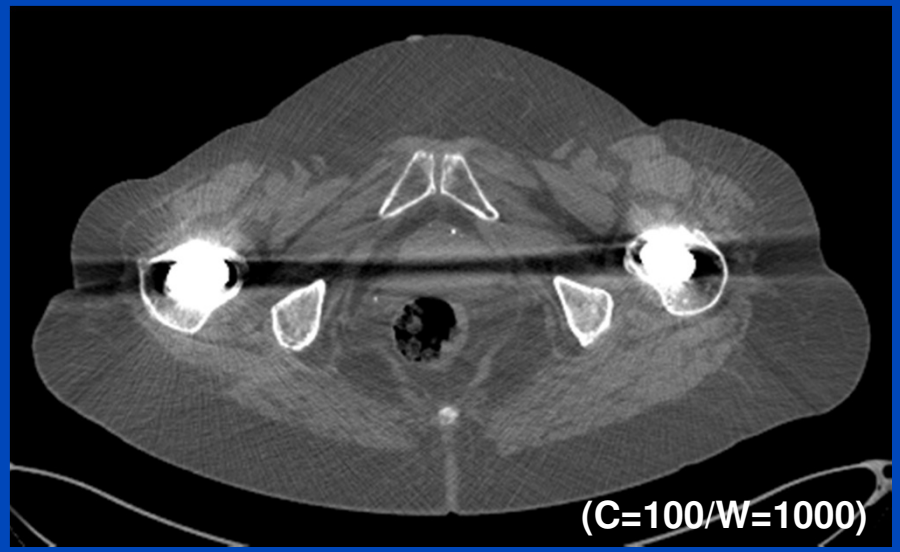
Normalized Metal Artifact Reduction (NMAR)



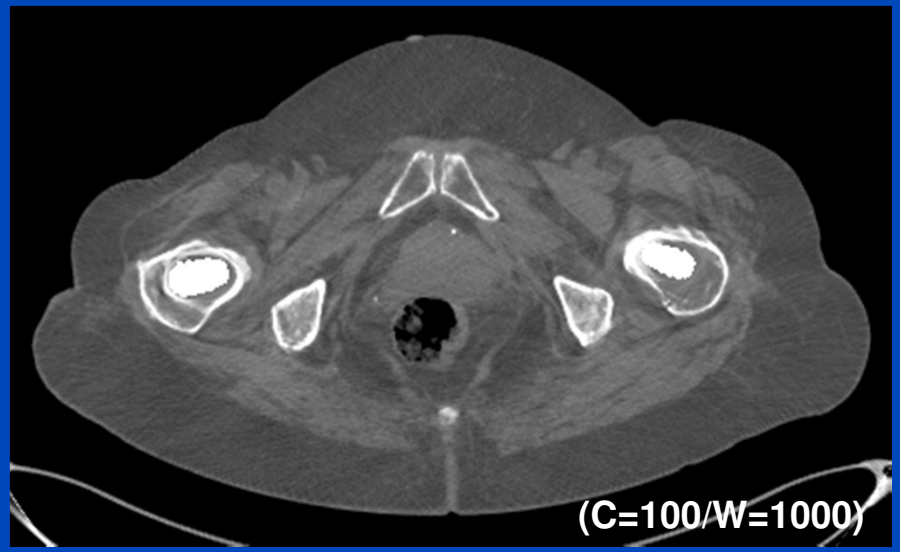
E. Meyer, R. Raupach, M. Lell, B. Schmidt, and M. Kachelrieß, "Normalized metal artifact reduction (NMAR) in computed tomography", Med. Phys., 37(10):5482-5493, October 2010.

Results: NMAR

Uncorrected image

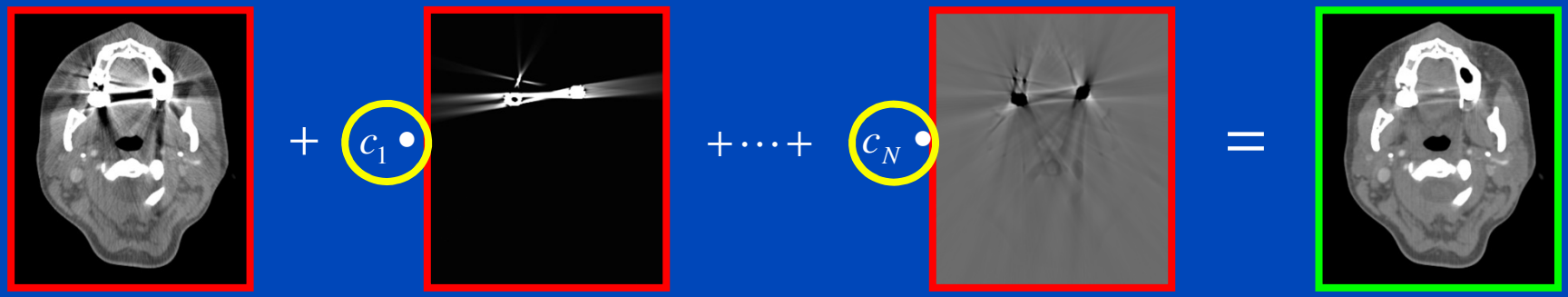


NMAR image



Patient with bilateral hip endoprosthesis, Siemens Somatom Definition

Empirical Beam Hardening and Scatter Correction (EBHSC)



Uncorrected image U

Basis image B_1 (Beam hardening)

Basis image B_N (Beam hardening)

Corrected image

$$c_1 \ldots c_N = \arg\min_{c_1 \ldots c_N} \mathrm{f}_{\mathrm{cost}}\left(U - \sum_{i=1}^{N} c_i B_i\right)$$

E. Meyer, C. Maaß, M. Baer, R. Raupach, B. Schmidt, and M. Kachelrieß, "Empirical Scatter Correction (ESC): A New CT Scatter Correction Method and its Application to Metal Artifact Reduction", IEEE Medical Imaging Conference Record 2010, pp. 2036-2041, 2010.

Basis Images

Beam Hardening Basis Images*

p : beam hardening-corrected projections

p_0 : water-precorrected projections of tissue

p_m : projections of metal

$$p(p_0, p_m) = \sum_{ij} c_n p_0^i p_m^j =$$

$$= p_0 + c_1 p_m + c_2 p_0 p_m + c_3 p_m^2 + \ldots$$

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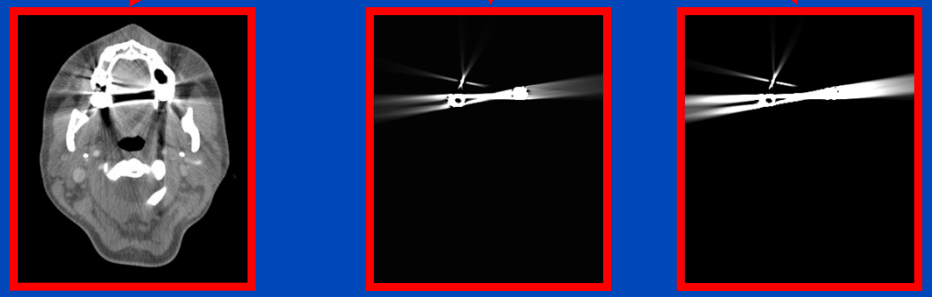


Scatter Basis Images

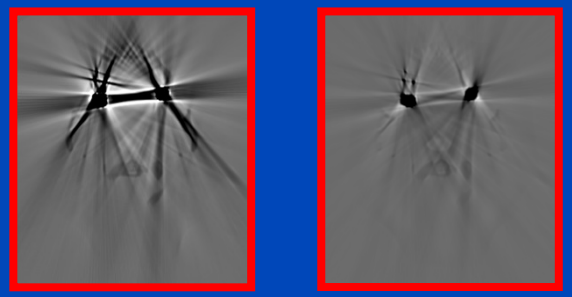
I_S : Scatter intensity

I_F : Forward scatter intensity

K : Scatter kernel

$$I_S(a,b,c) = I_F(a) * K(b,c)$$

Different sets of model parameters** a, b, c



*Y. Kyriakou, E. Meyer, D. Prell, and M. Kachelrieß, “Empirical beam hardening correction (EBHC) for CT”, Med. Phys., vol. 37, pp. 5179-5187, 2010.

**B. Ohnesorge et al., “Efficient object scatter correction algorithm for third and fourth generation CT scanners,” EuRad., vol. 9, pp. 563-569, 1999.

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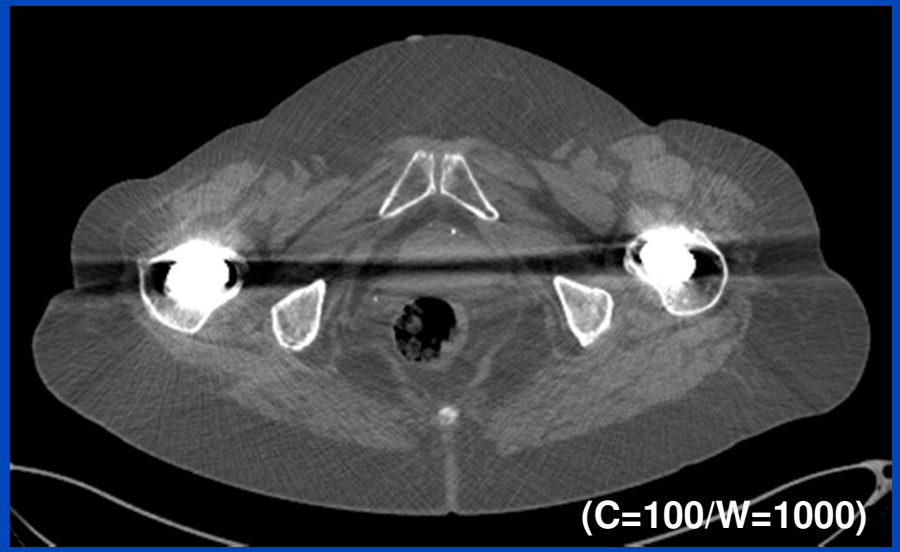
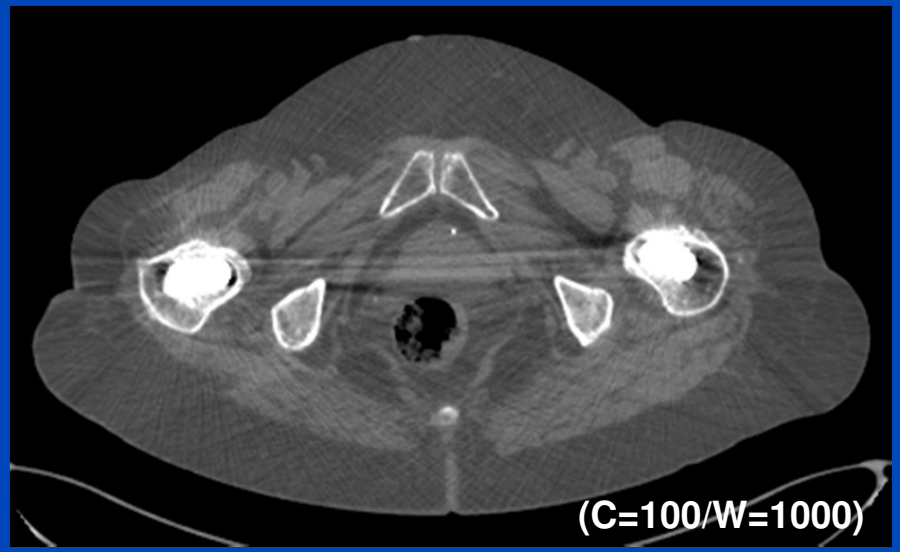
Results: EBHSC

Uncorrected image



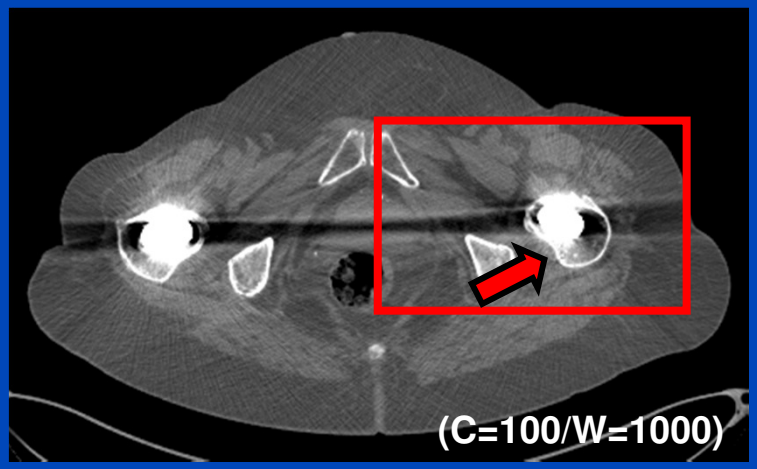
EBHSC image



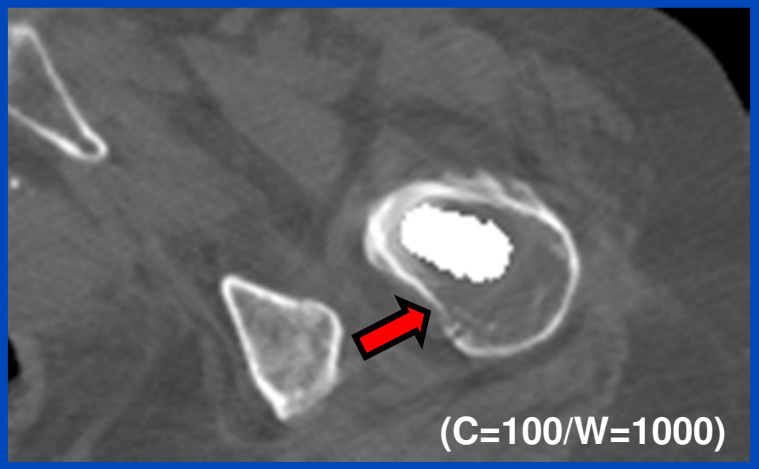
Patient with bilateral hip endoprosthesis, Siemens Somatom Definition

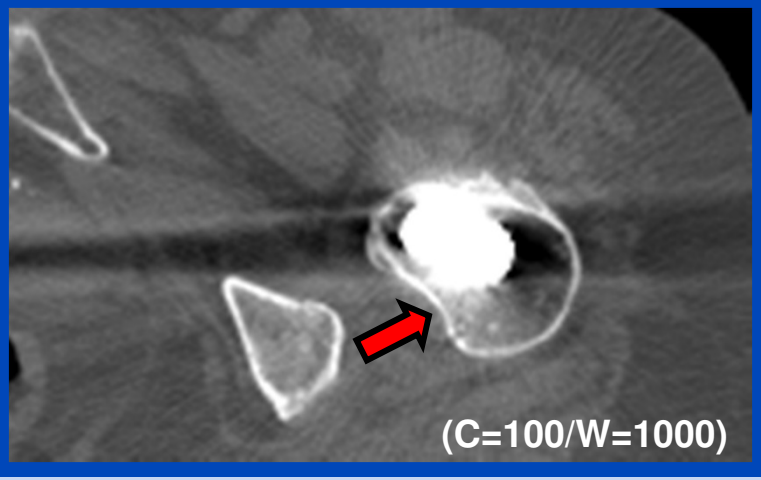
Results - Comparison

Uncorrected

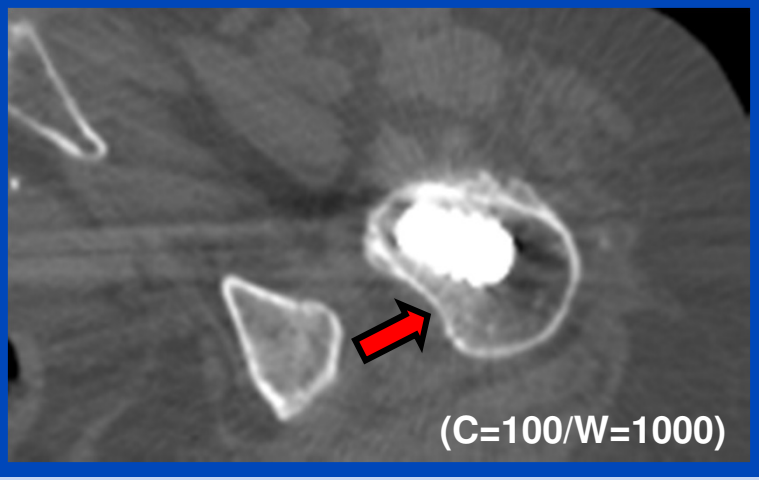


NMAR





EBHSC

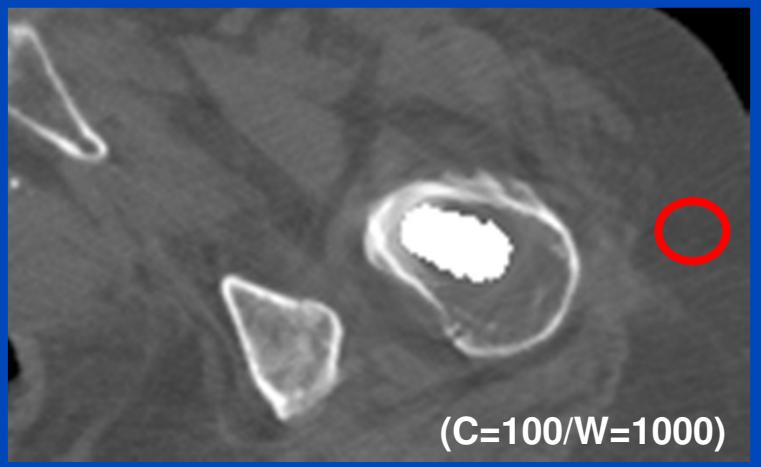


Results - Comparison

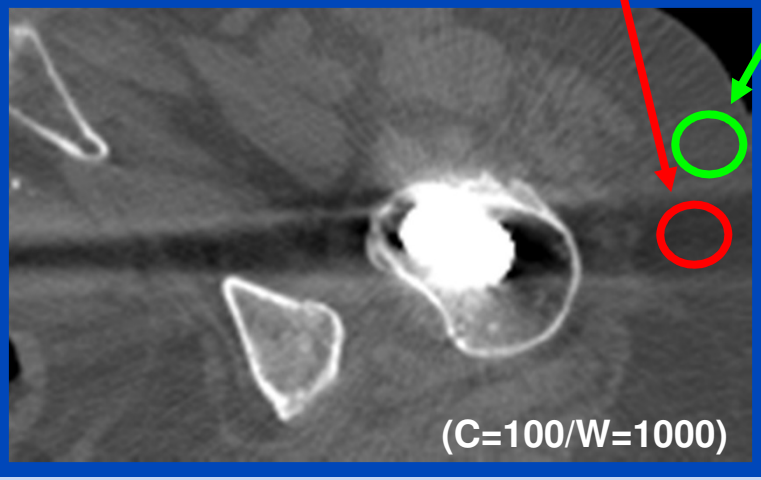
Mean difference of ROIs in artifacts compared to baseline

	Uncorr	EBHSC	NMAR
Mean Difference	128 HU	14 HU	5 HU

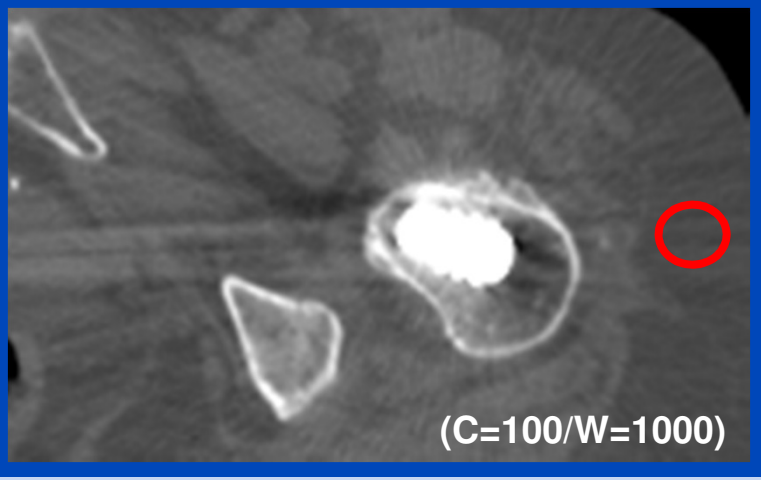
NMAR



Uncorrected



EBHSC



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Conclusion

- Full replacement by NMAR is a robust method for different kinds of implants, especially for implants with dense materials or small implants.
- For less dense implants, EBHSC is a good alternative. It is based on a physical modeling of artifacts and all available data are used.

Thank You!

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