Iterative techniques for metal artifact reduction

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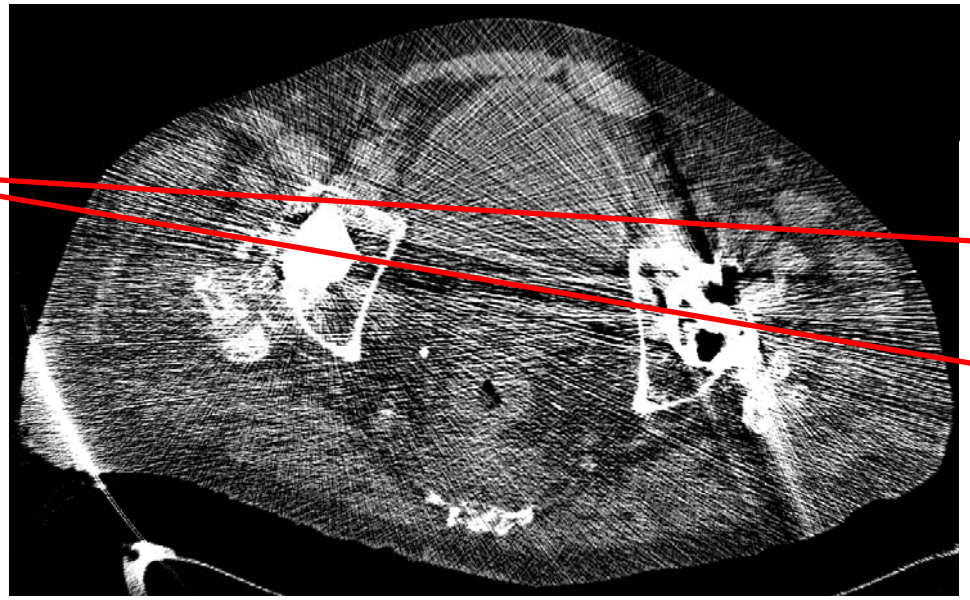
2011-08-11

CT metal artifacts



X-ray source

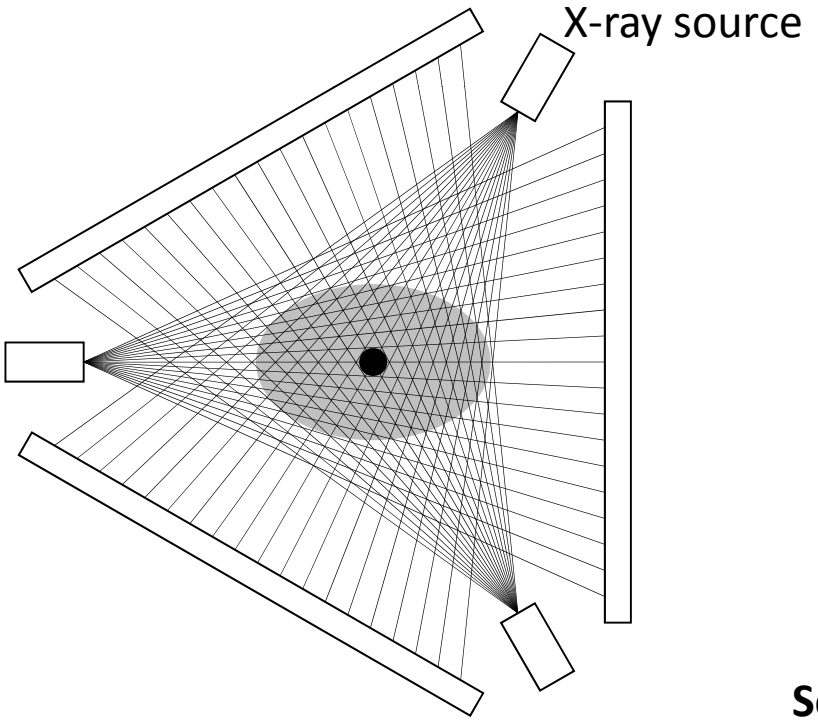
Low error

High error, due to:

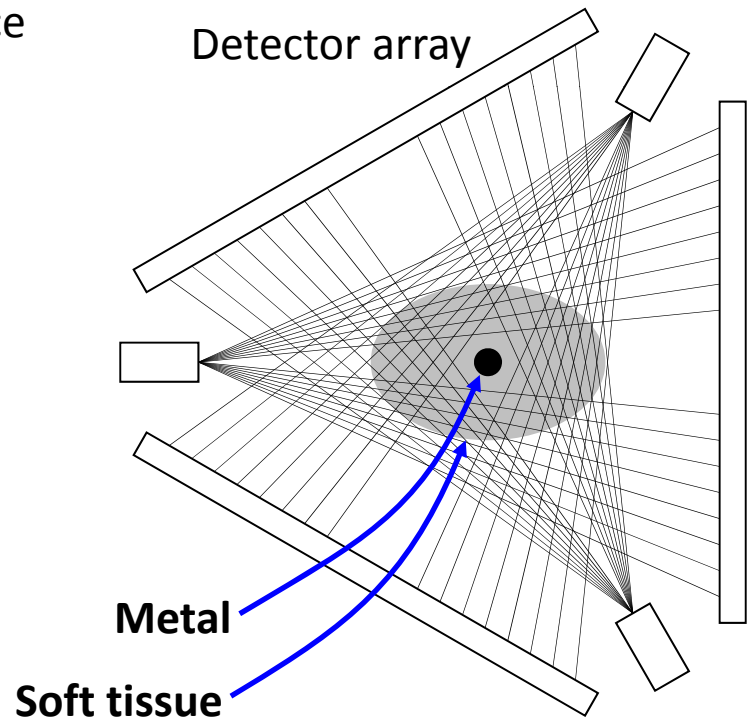
- Poisson noise
- Beam hardening
- Scatter
- Motion

Metal deletion technique (MDT)

Use all of the data to reconstruct the metal pixels …



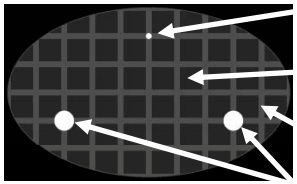
… but only use non-metal data to reconstruct non-metal pixels.

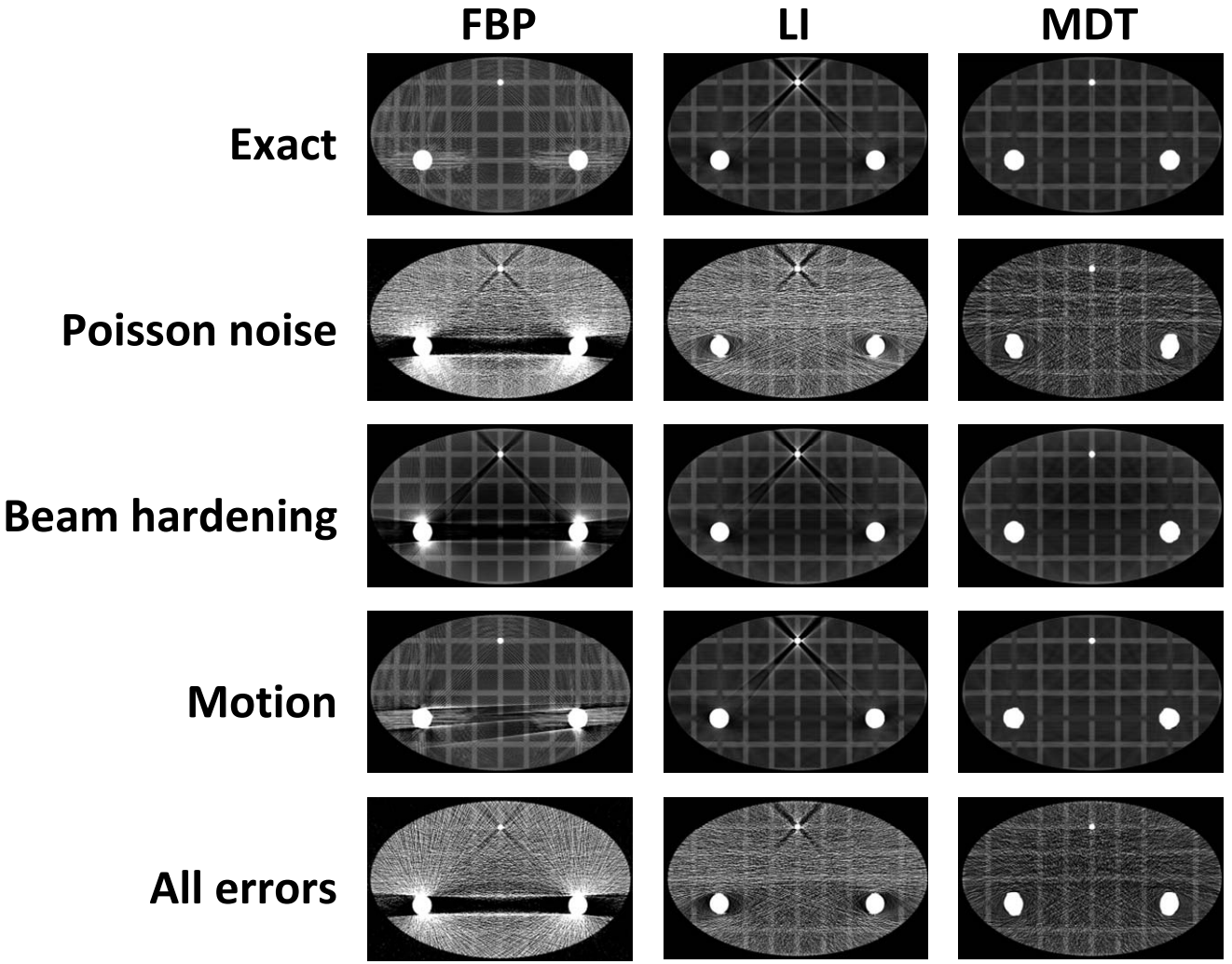


Metal deletion technique (MDT)

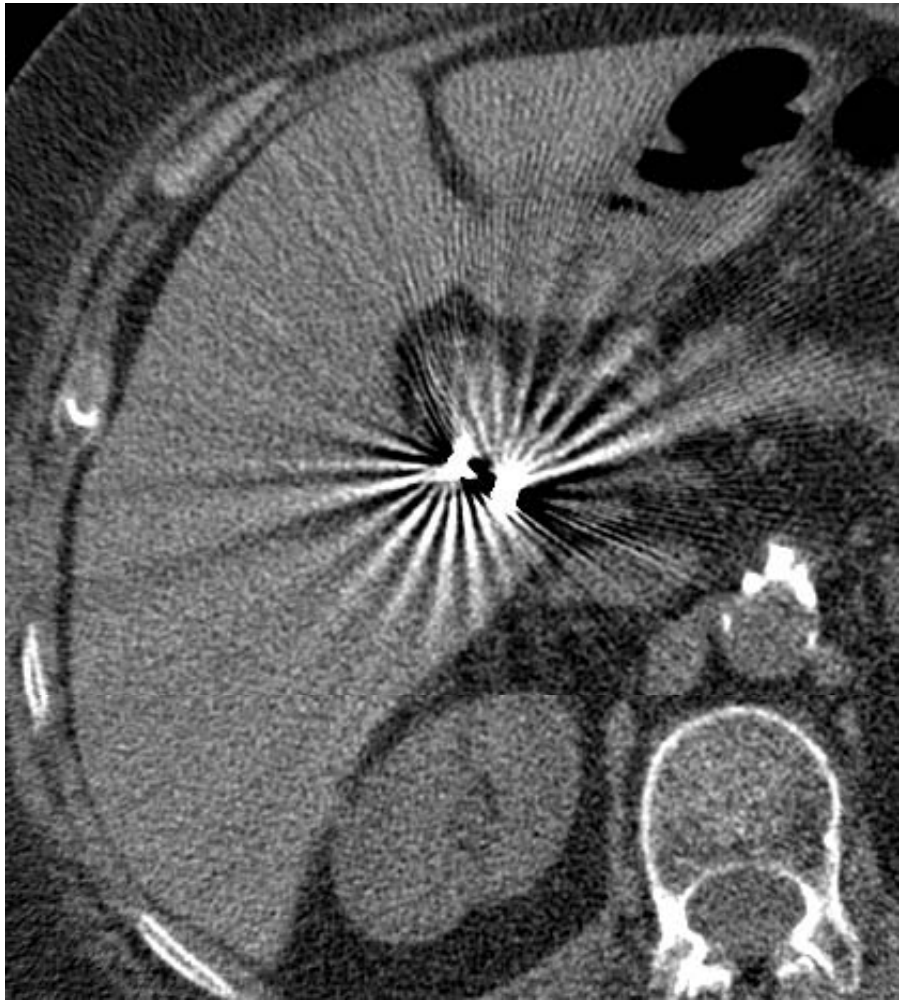
Delete metal pixels, then use forward projection iteratively to replace detector measurements that involve metal.

Simulated scans

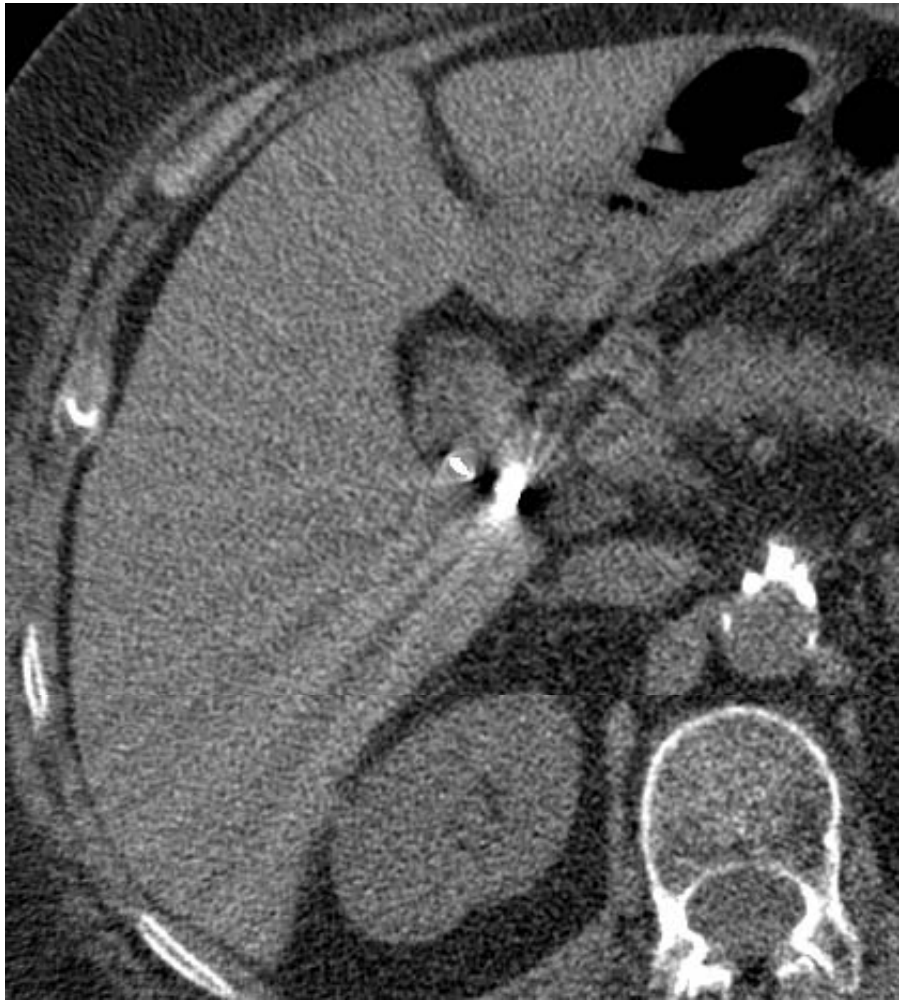




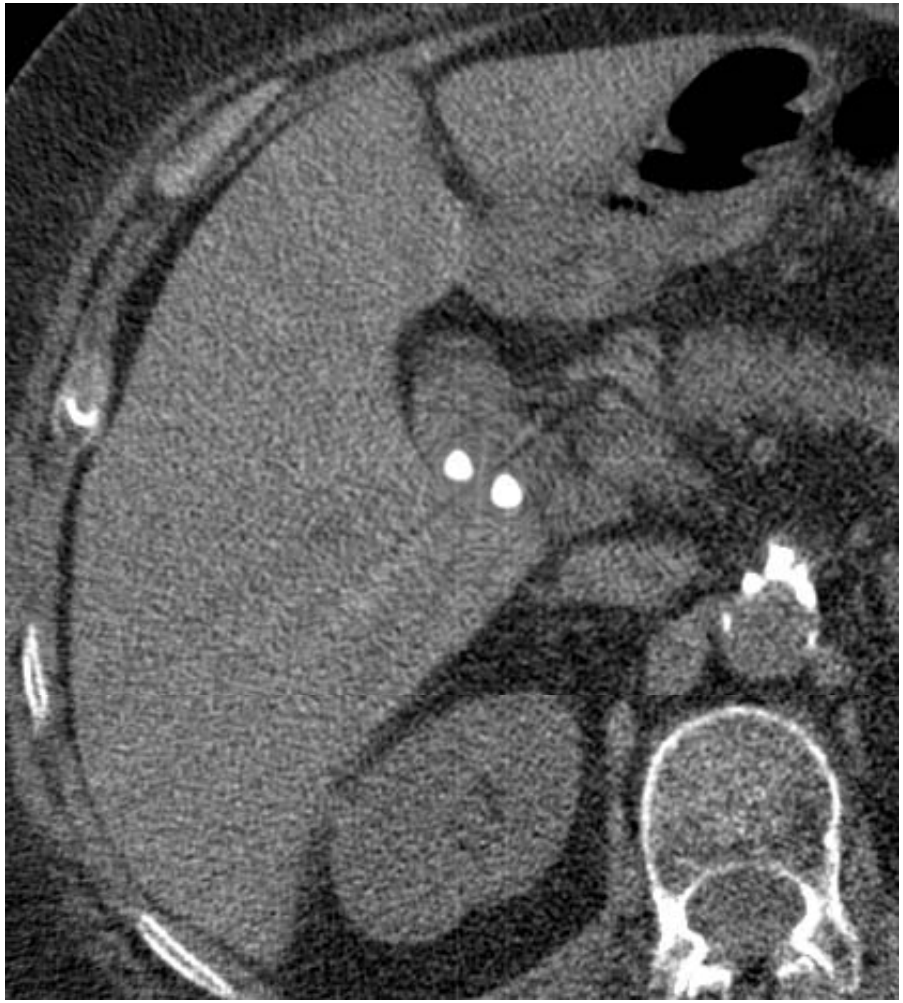
Cholecystectomy clips: FBP



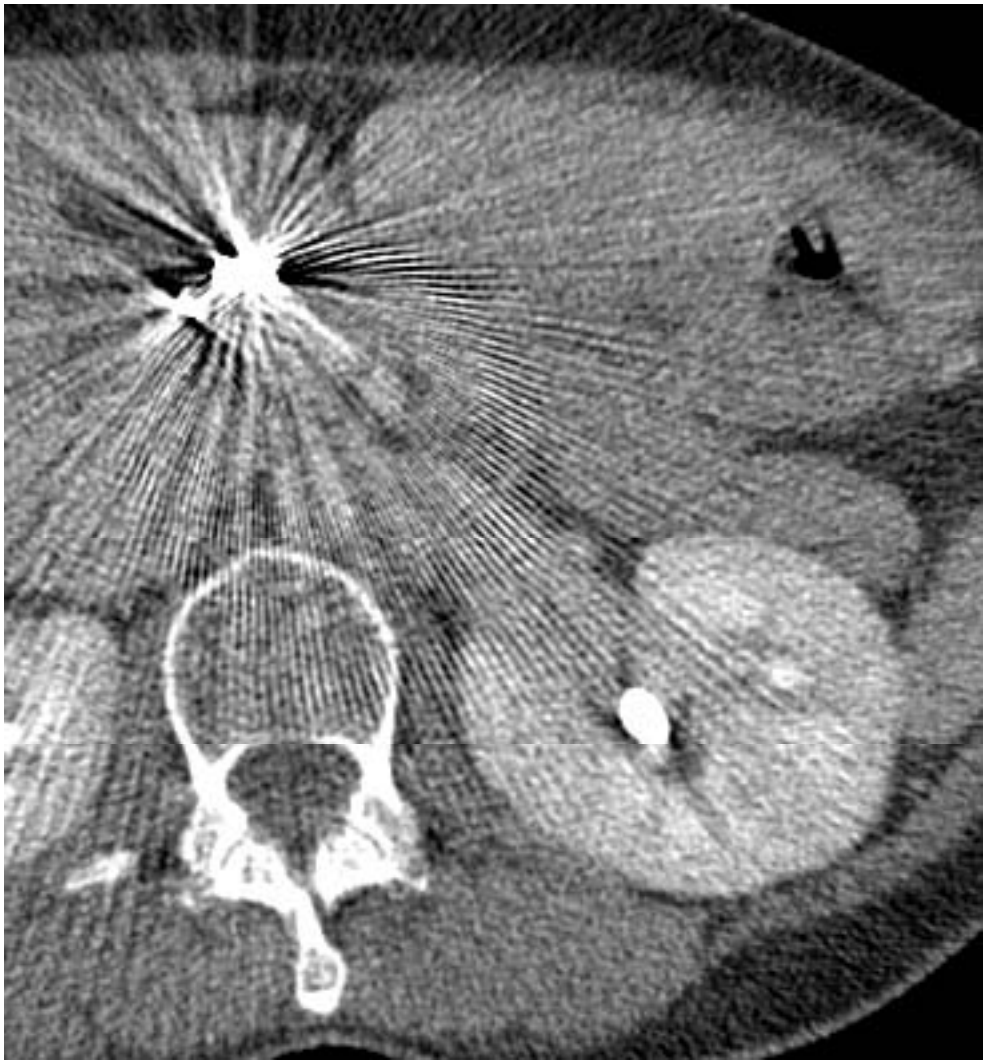
Cholecystectomy clips: LI



Cholecystectomy clips: MDT



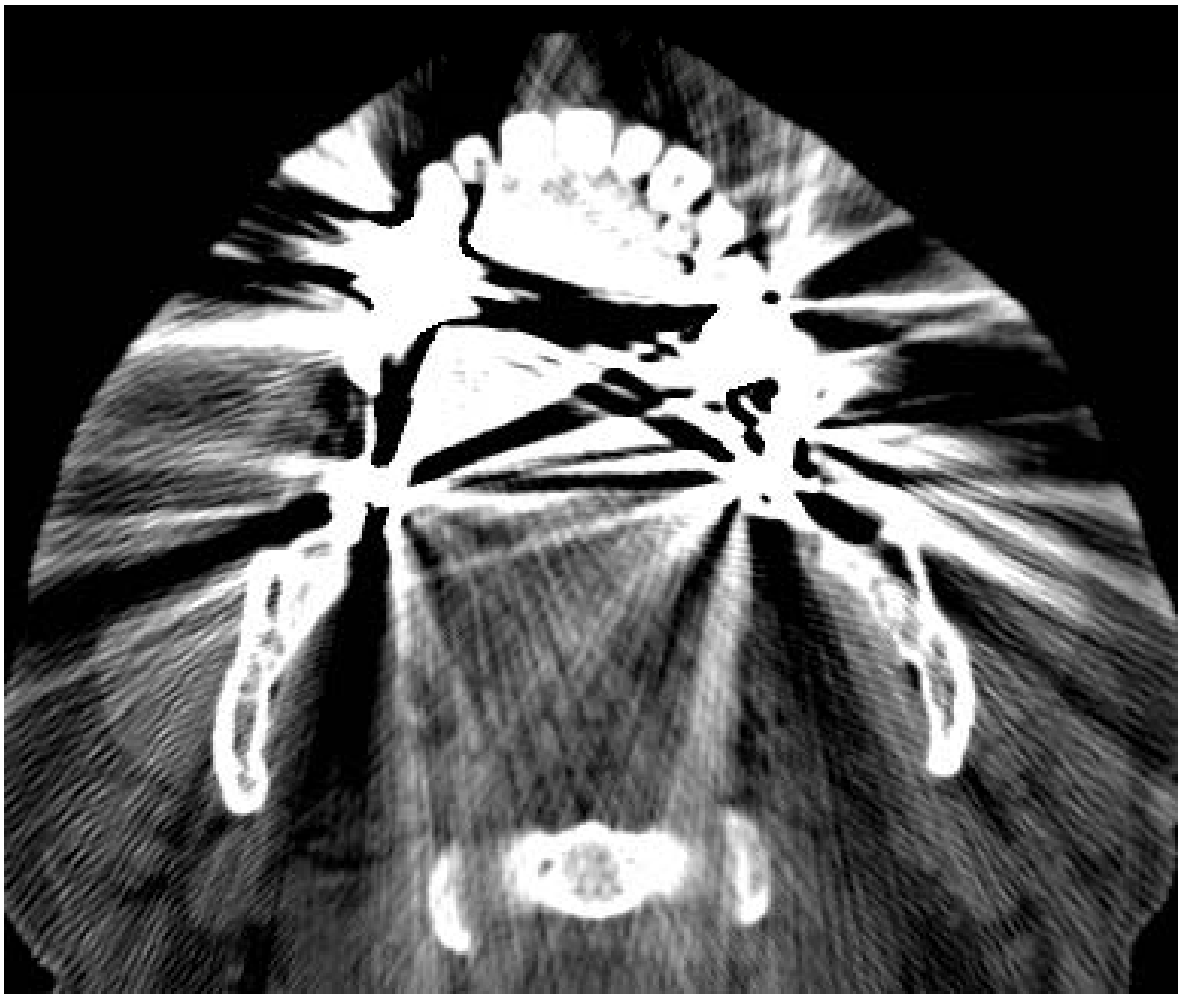
Embolization coils: FBP



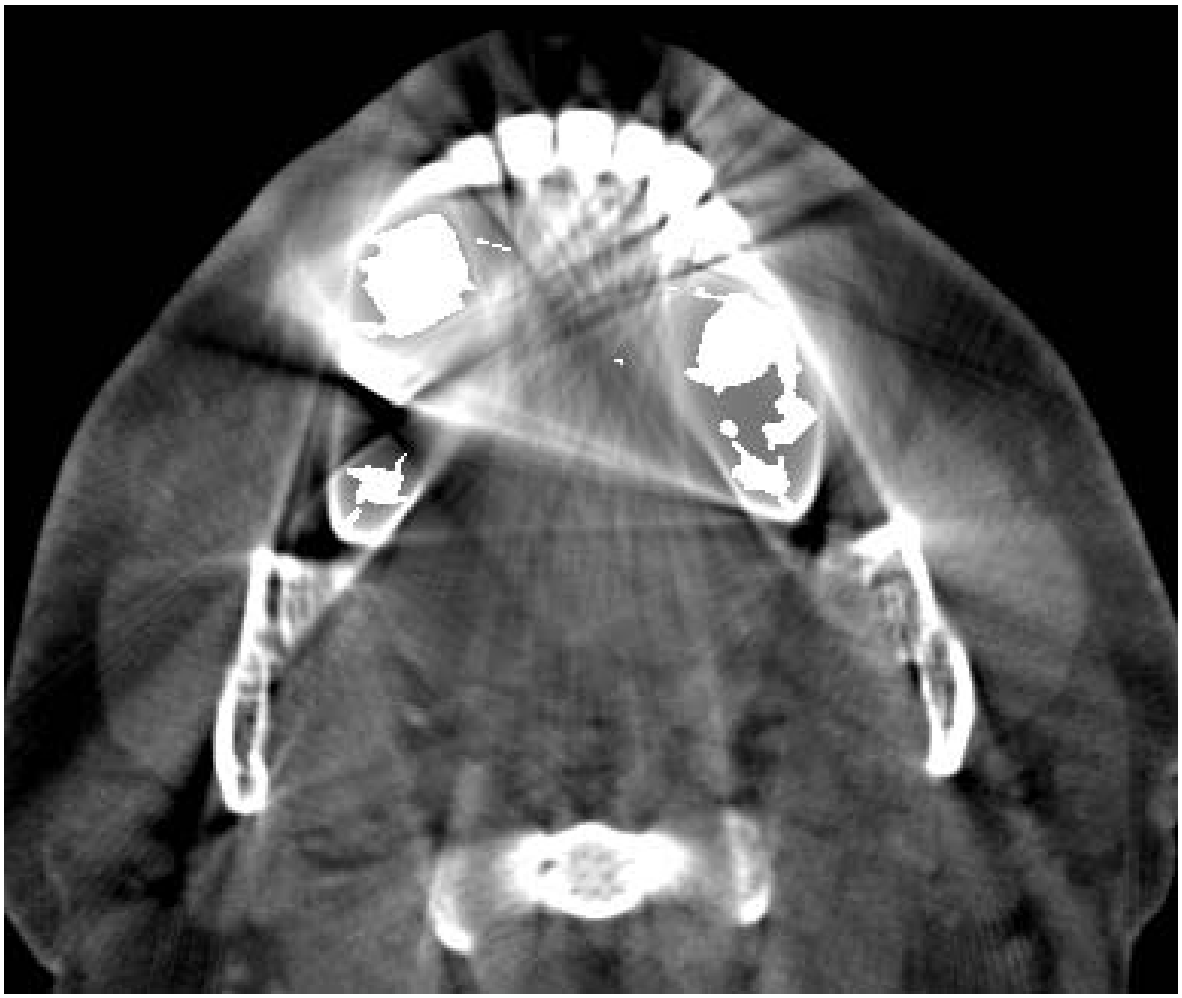
Embolization coils: LI

Embolization coils: MDT

Dental fillings: FBP

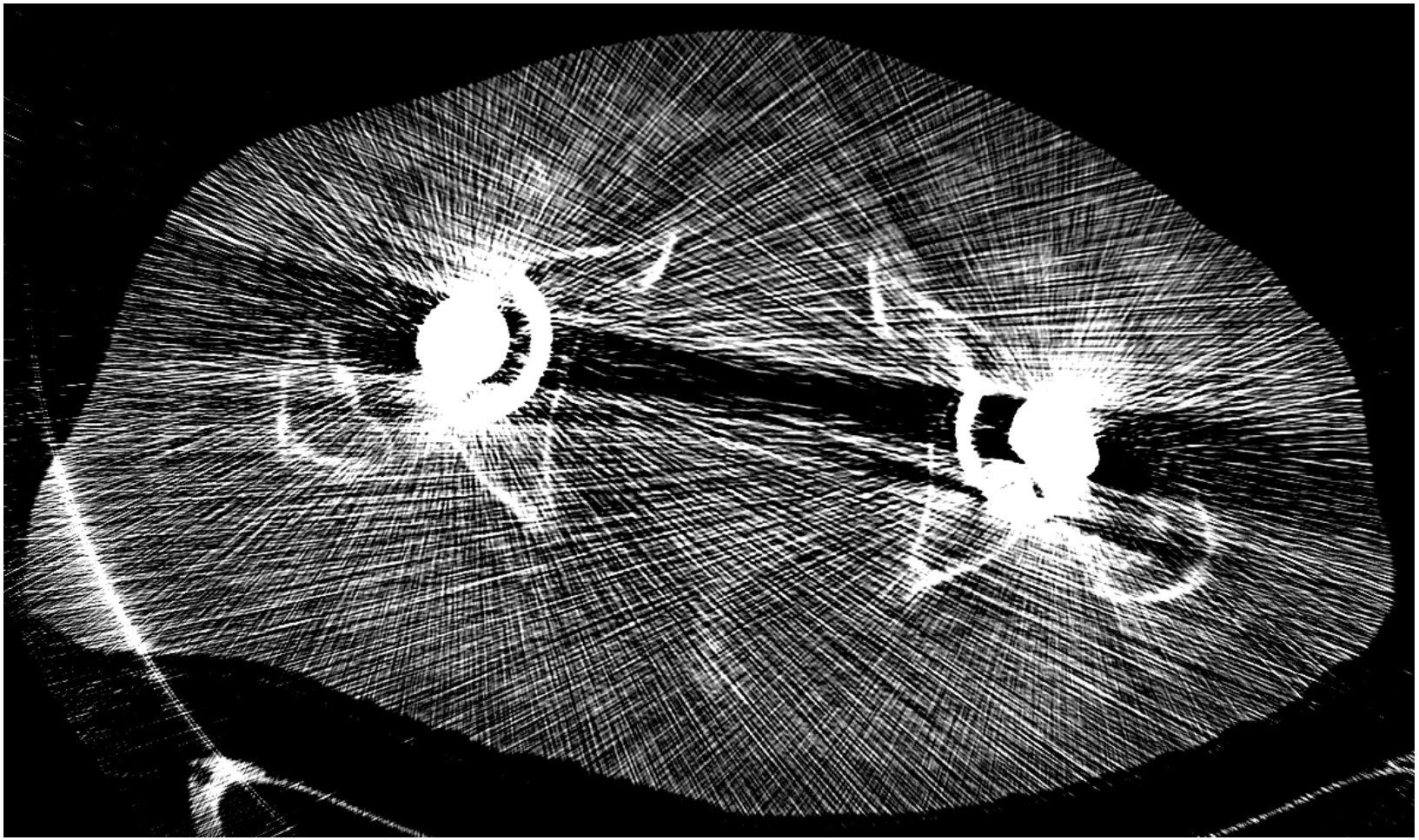


Dental fillings: LI

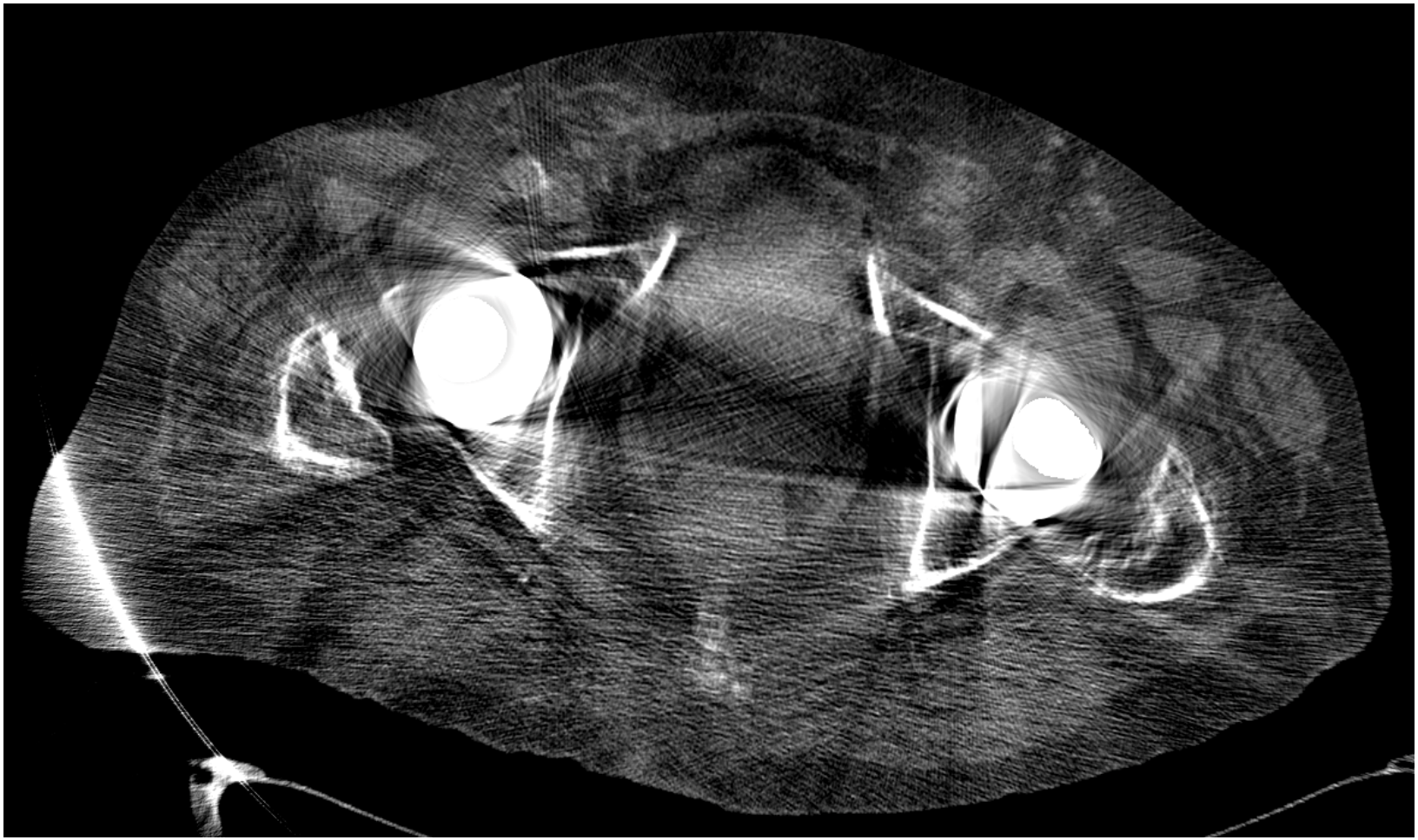


Dental fillings: MDT

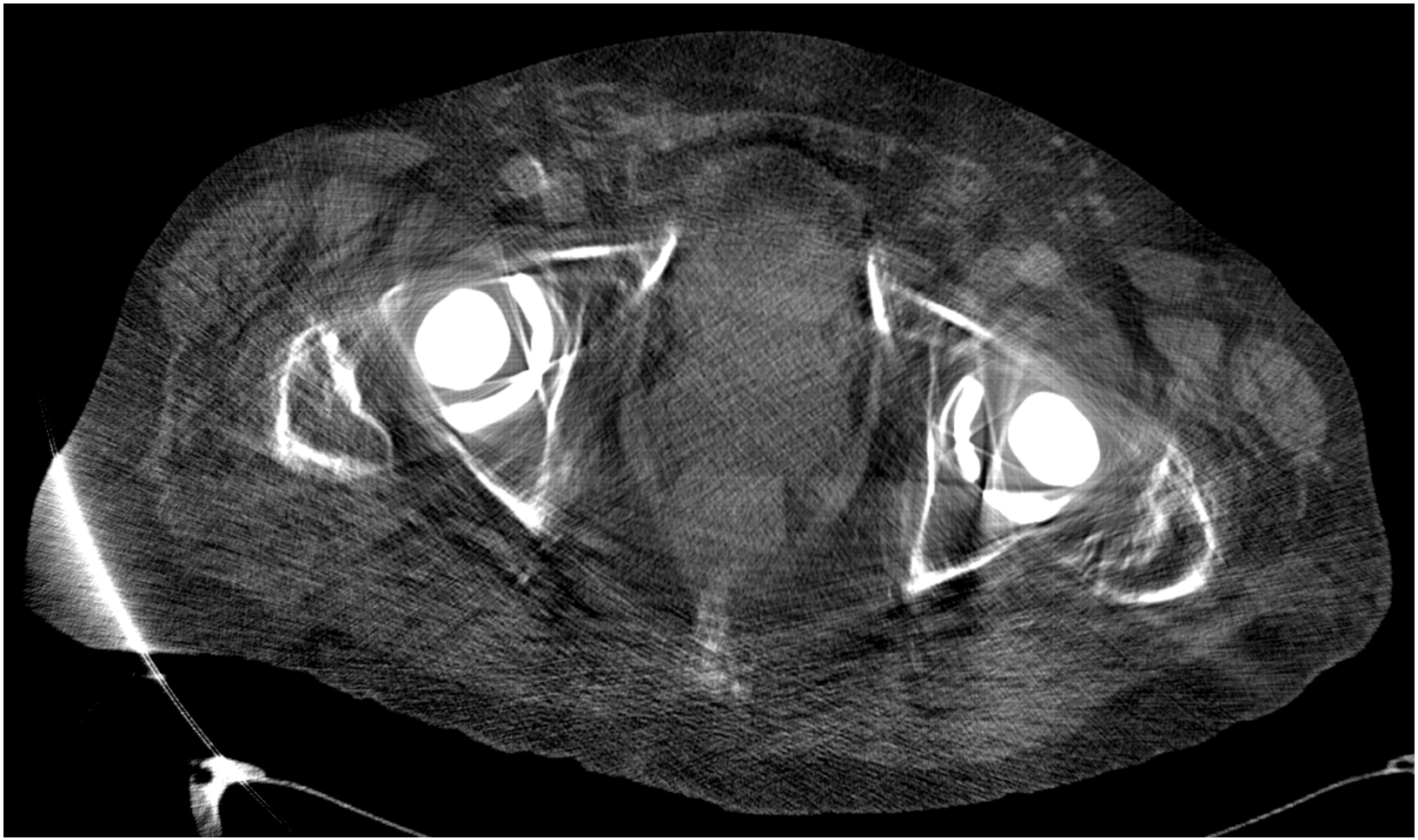
Hip replacements: FBP



Hip replacements: LI



Hip replacements: MDT



Clinical scans

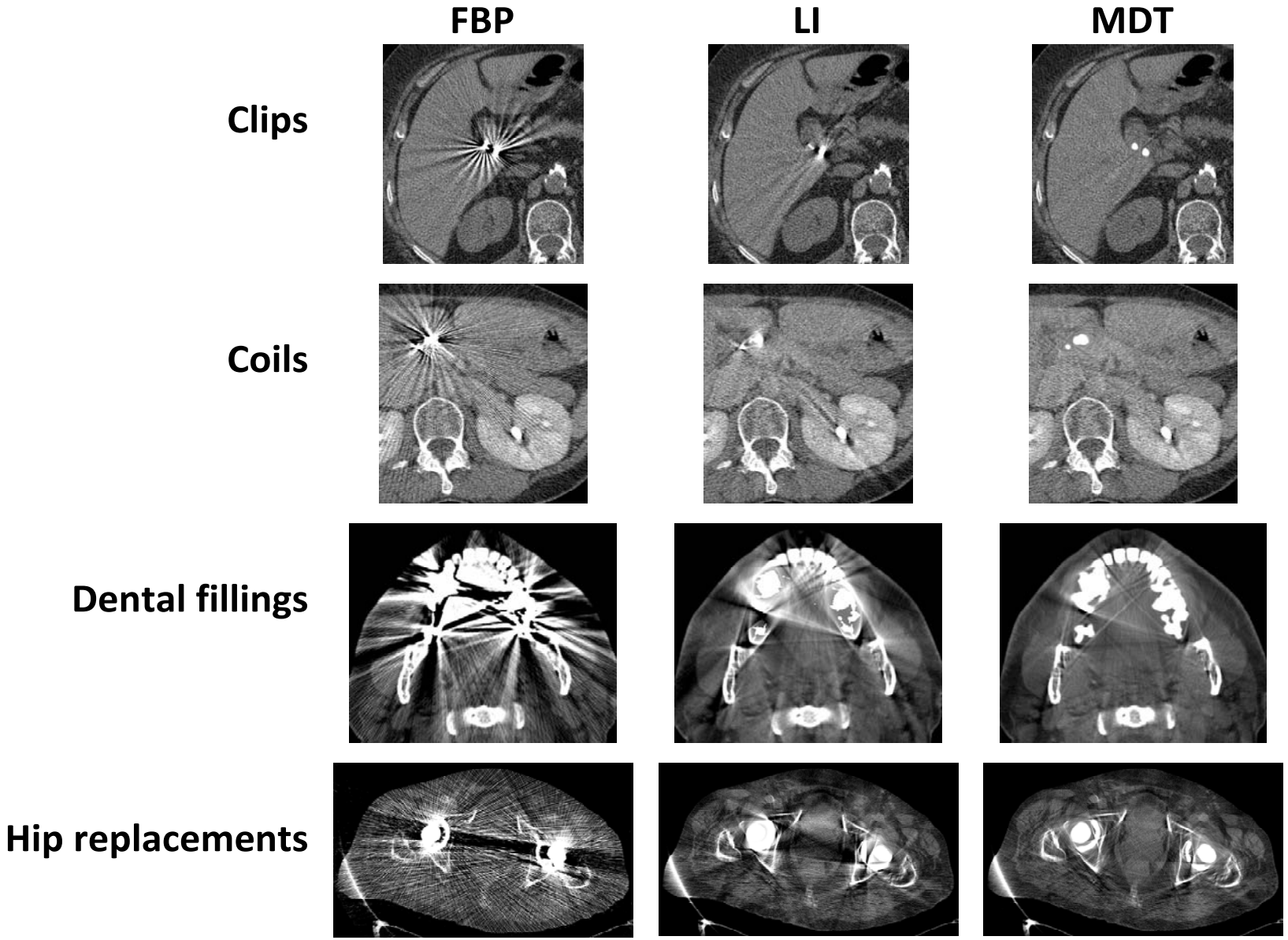
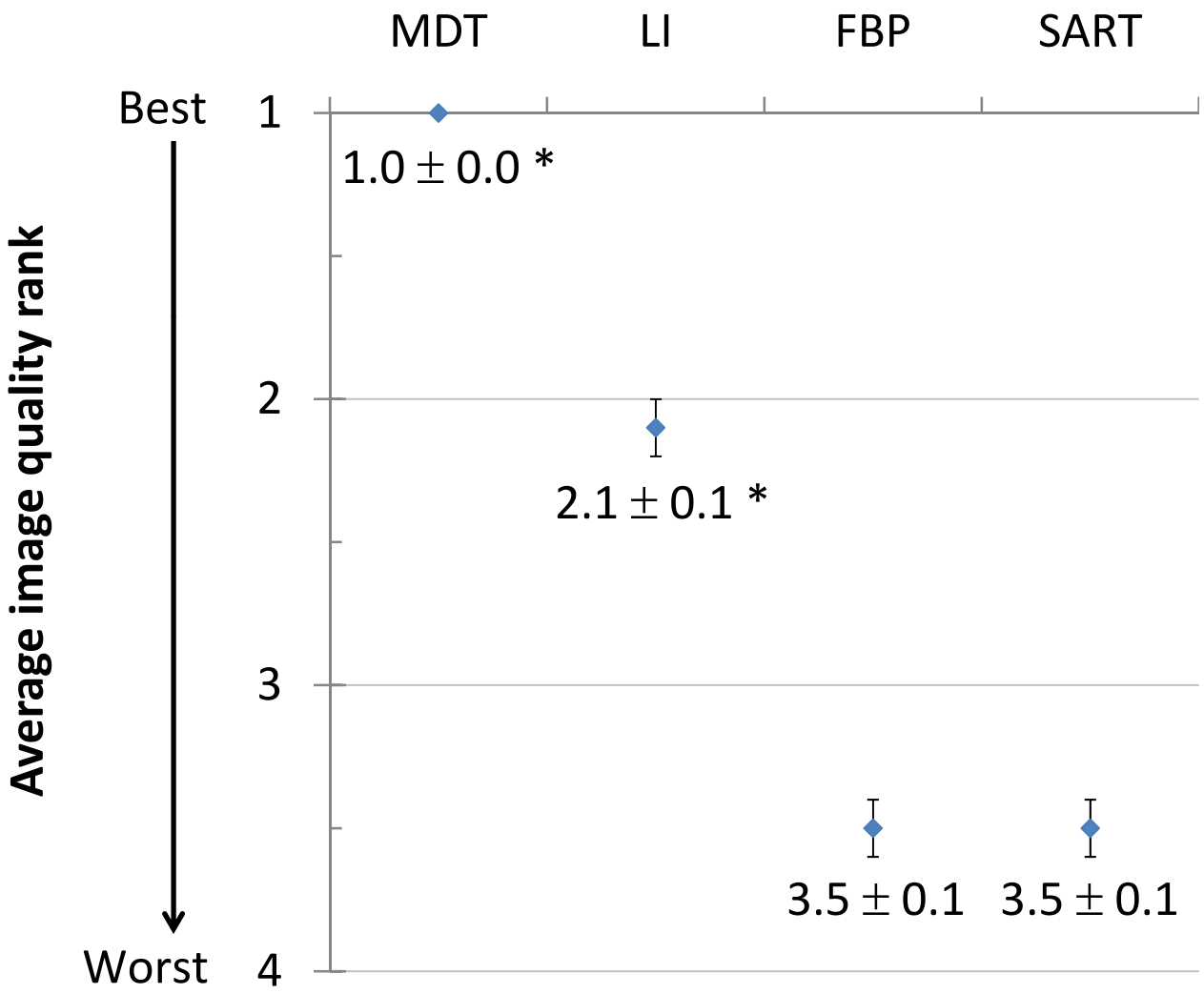


Image quality rank (raw data)



11 scans
178 slices

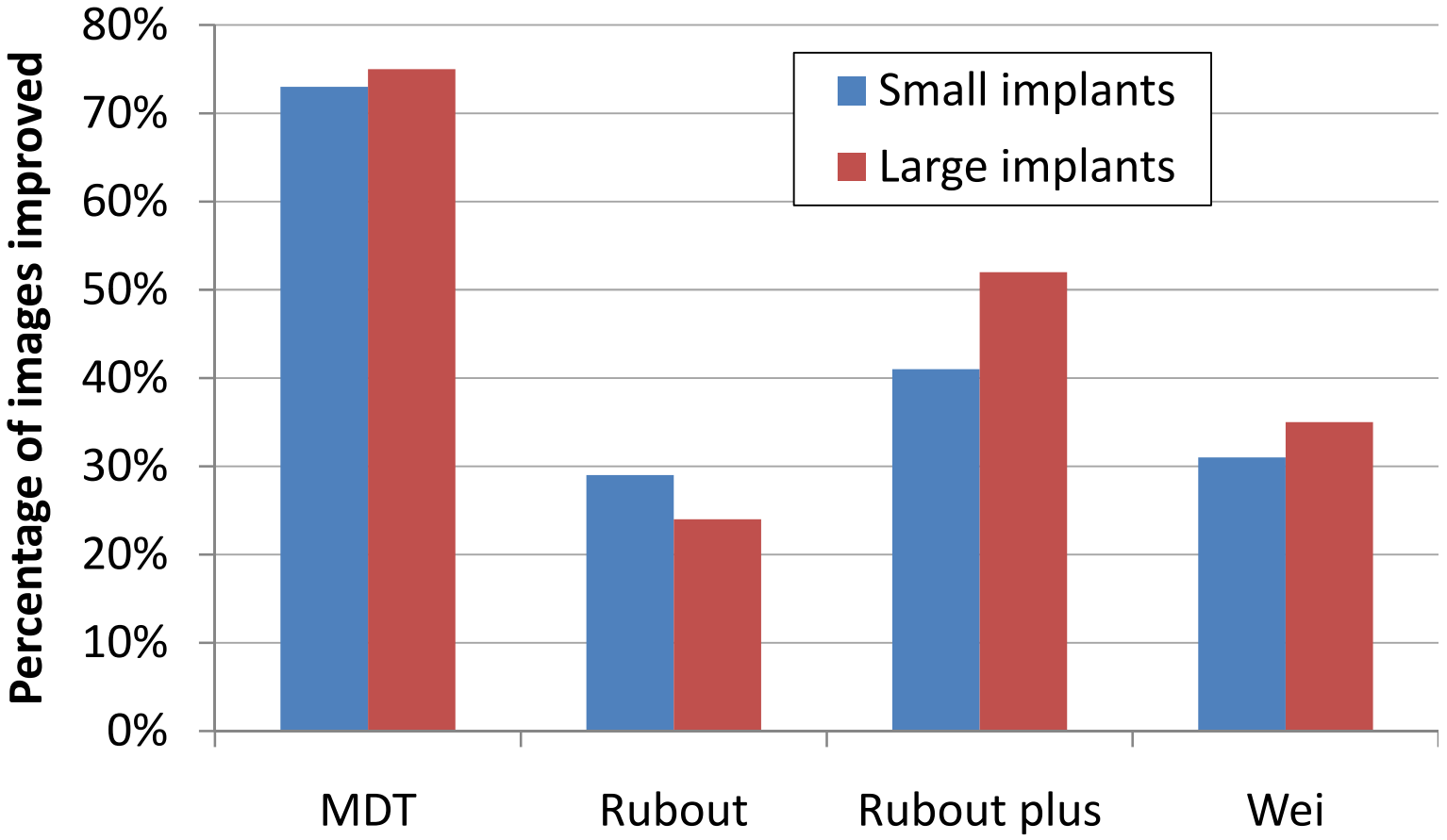
Average ± S.E.M.

* statistically significant difference

Metal artifact reduction from DICOM

If raw data is not available, it can be simulated by forward projecting DICOM files generated by the scanner.

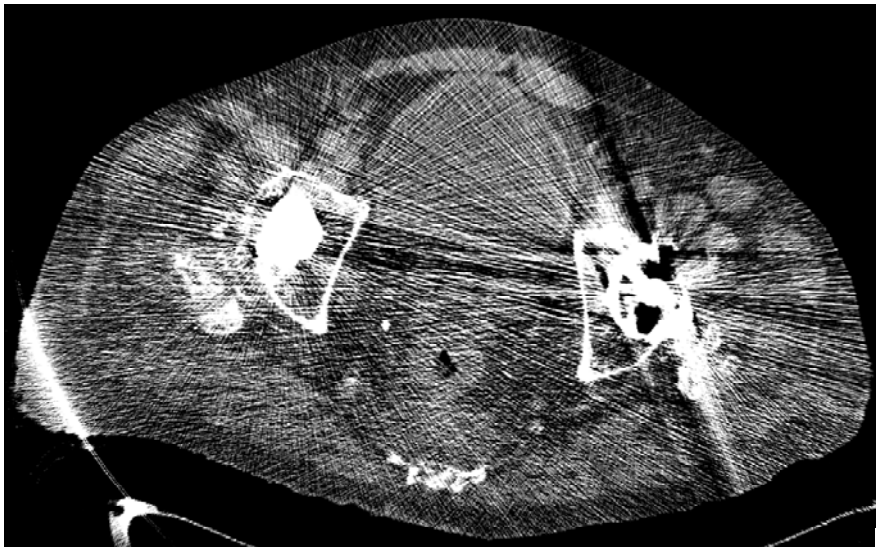
Improved image quality (DICOM)



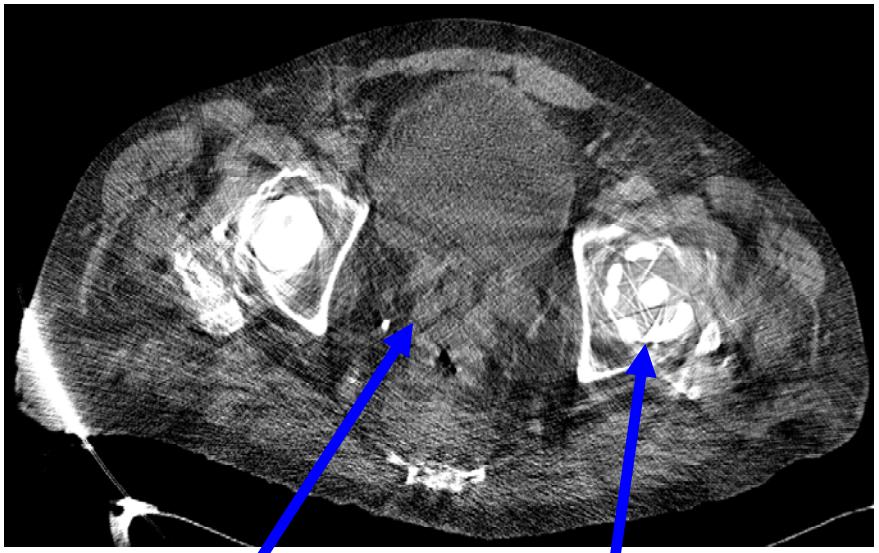
80 slices. Data from Caroline Golden, Sam Mazin, et al.

Improved diagnosis

FBP

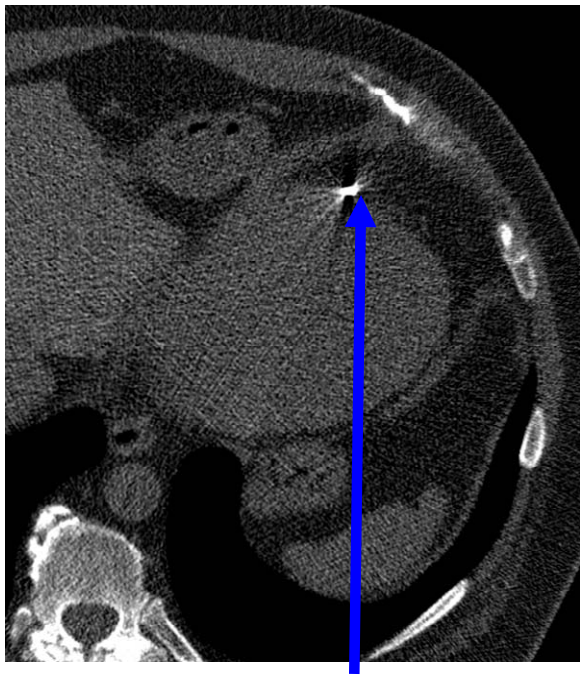


MDT



Improved diagnosis

FBP

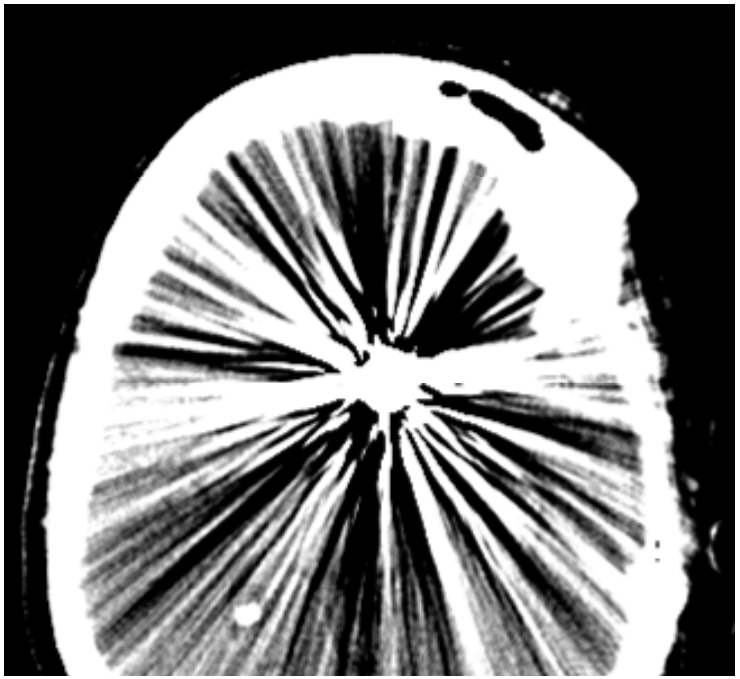


Apparent tip of the pacer wire

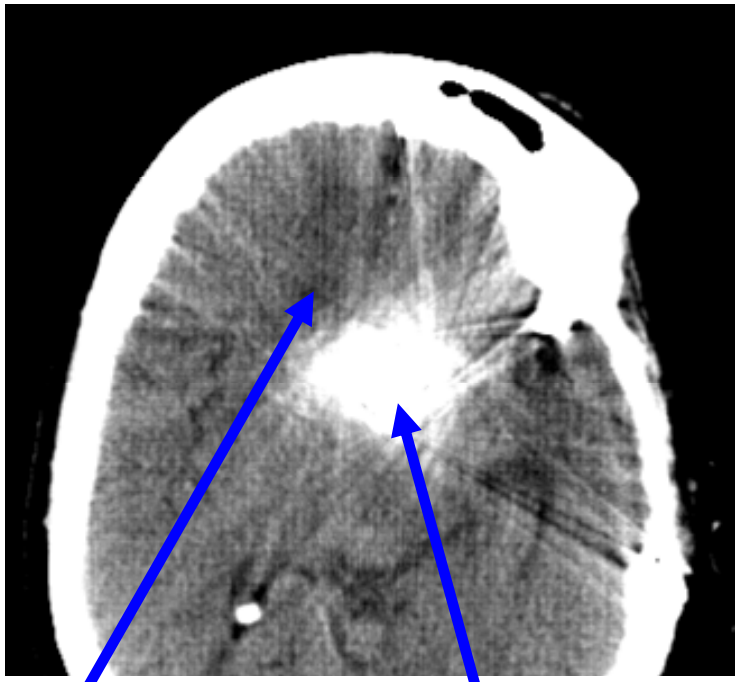
MDT

Improved diagnosis (DICOM)

FBP



MDT

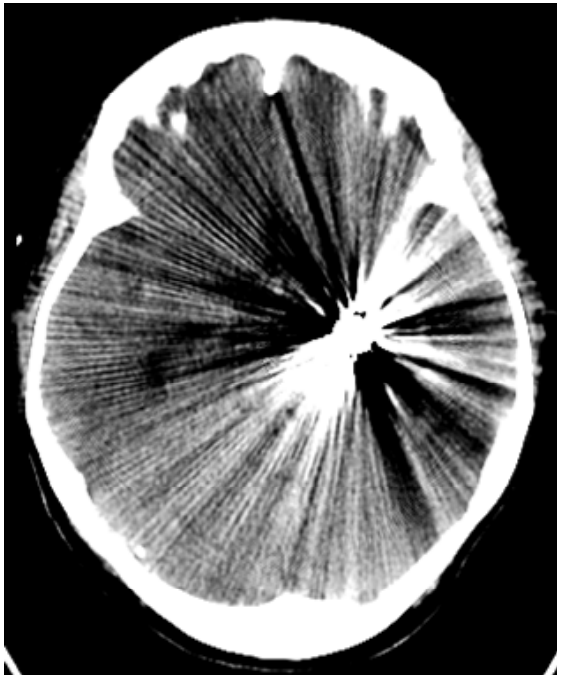


Stroke

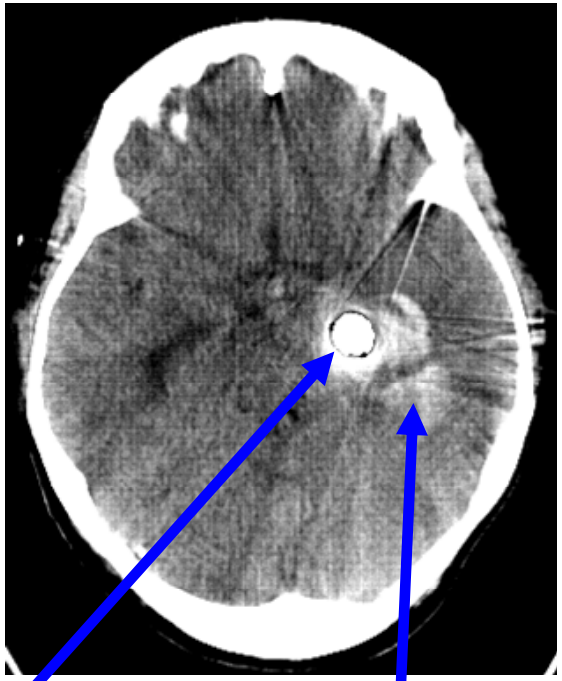
Aneurysm coil

Improved diagnosis (DICOM)

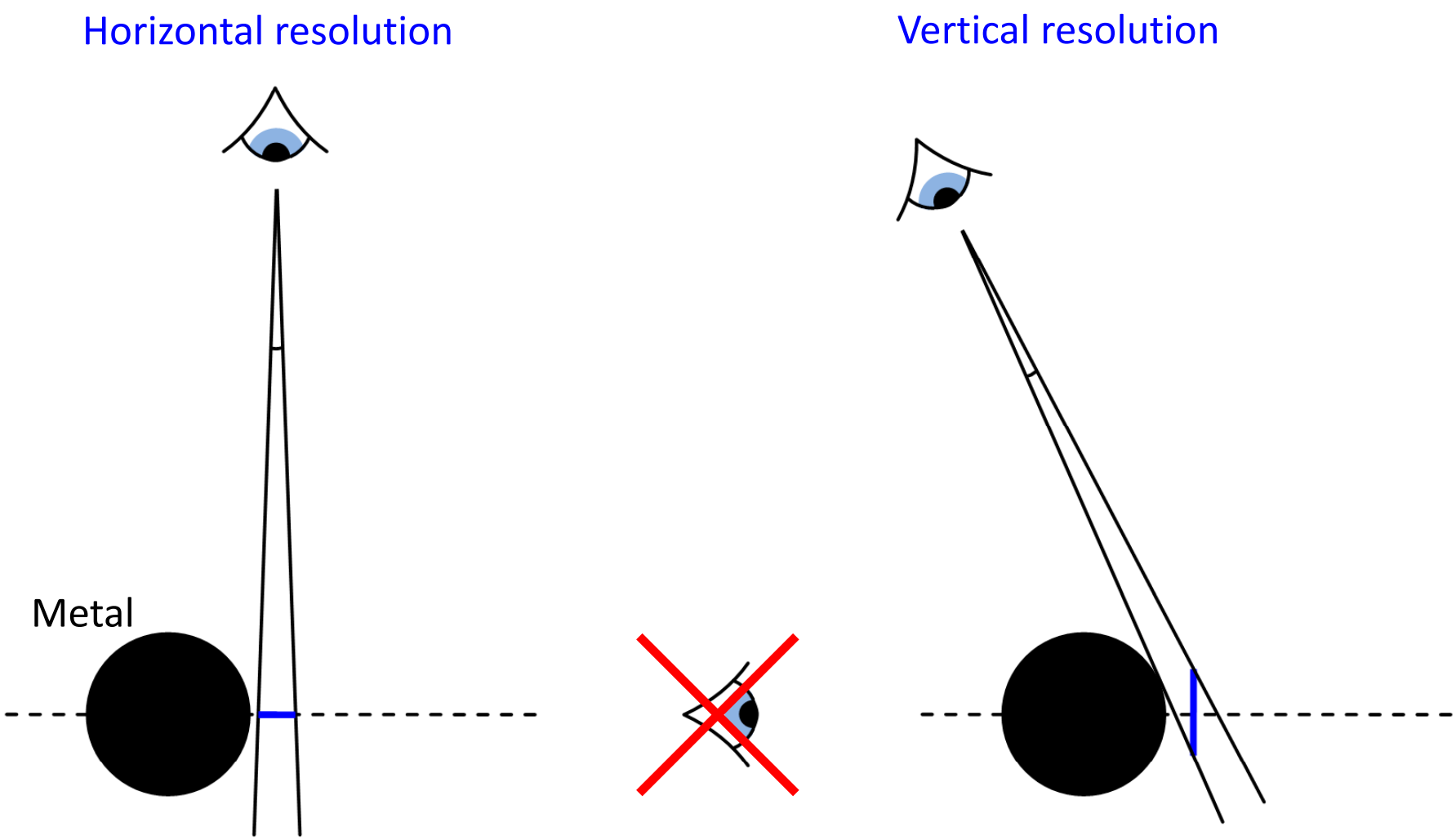
FBP



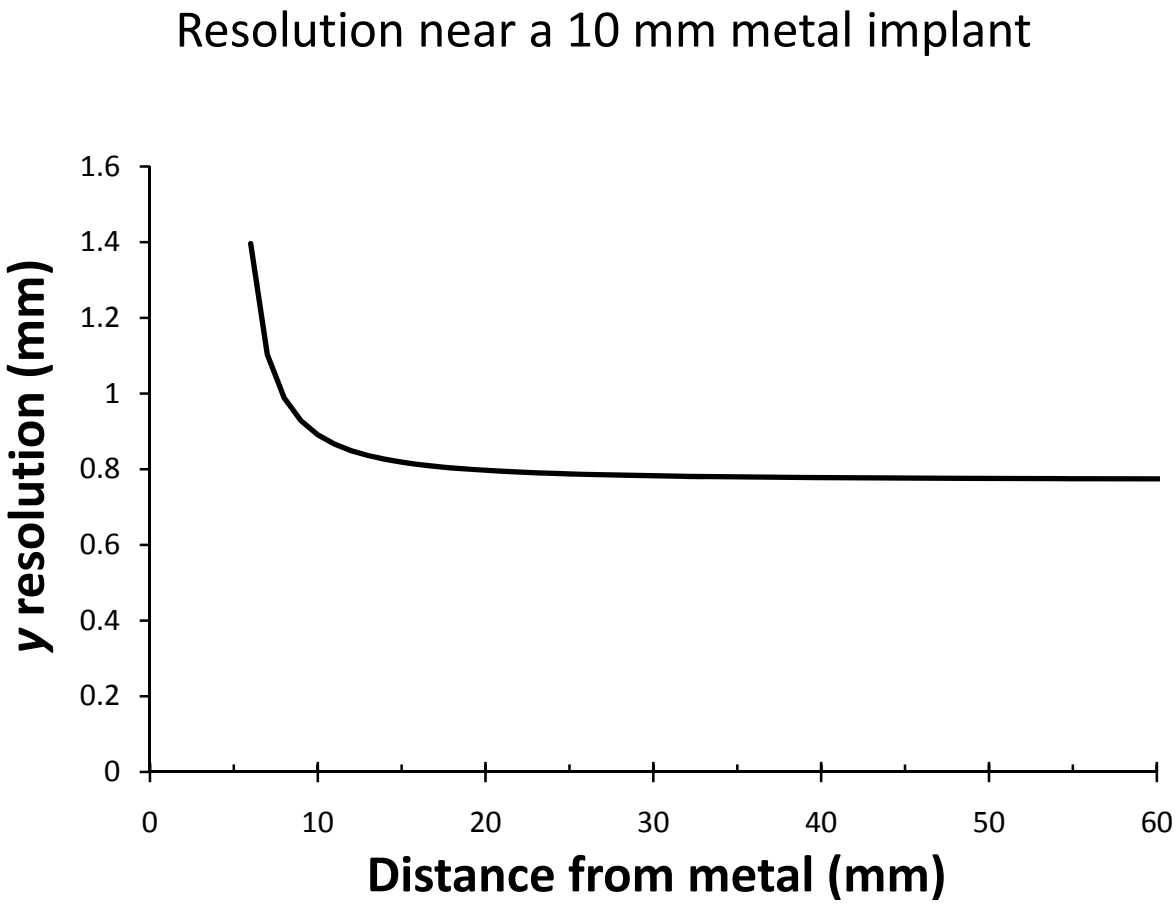
MDT



Decreased resolution near metal



Decreased resolution near metal



Conclusions

1. MDT reduces metal artifacts due to Poisson noise, beam hardening, and motion.
2. MDT has better image quality than other techniques (p=0.0005), and may change the diagnosis.
3. MDT works on a variety of scans, from hip replacements to moving pacer wires.

Tips for using MDT

- Best results are obtained with small stationary implants: dental fillings, hip replacements, surgical clips, aneurysm coils.
- Suboptimal results are obtained with large implants: pedicle screws and complex orthopedic hardware
- Due to potential resolution loss, MDT must be reviewed in conjunction with the conventional FBP images.
- MDT should be performed on axial images. Coronal or sagittal images should be reformatted from axial MDT images.
- The metal causing the streaks must be visible on the image.
- MDT uses a fixed Hounsfield unit cutoff of 3000 to detect metal.

Acknowledgements

Dominik Fleischmann (Stanford)
Roland Bammer (Stanford)
Caroline Golden (National University of Ireland Galway)
Sam Mazin (Stanford)
Jon Abelson (Stanford)
Chris Beaulieu (Stanford)
Christoph Panknin (Siemens)

Funding: None

Thank you!

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Key references:

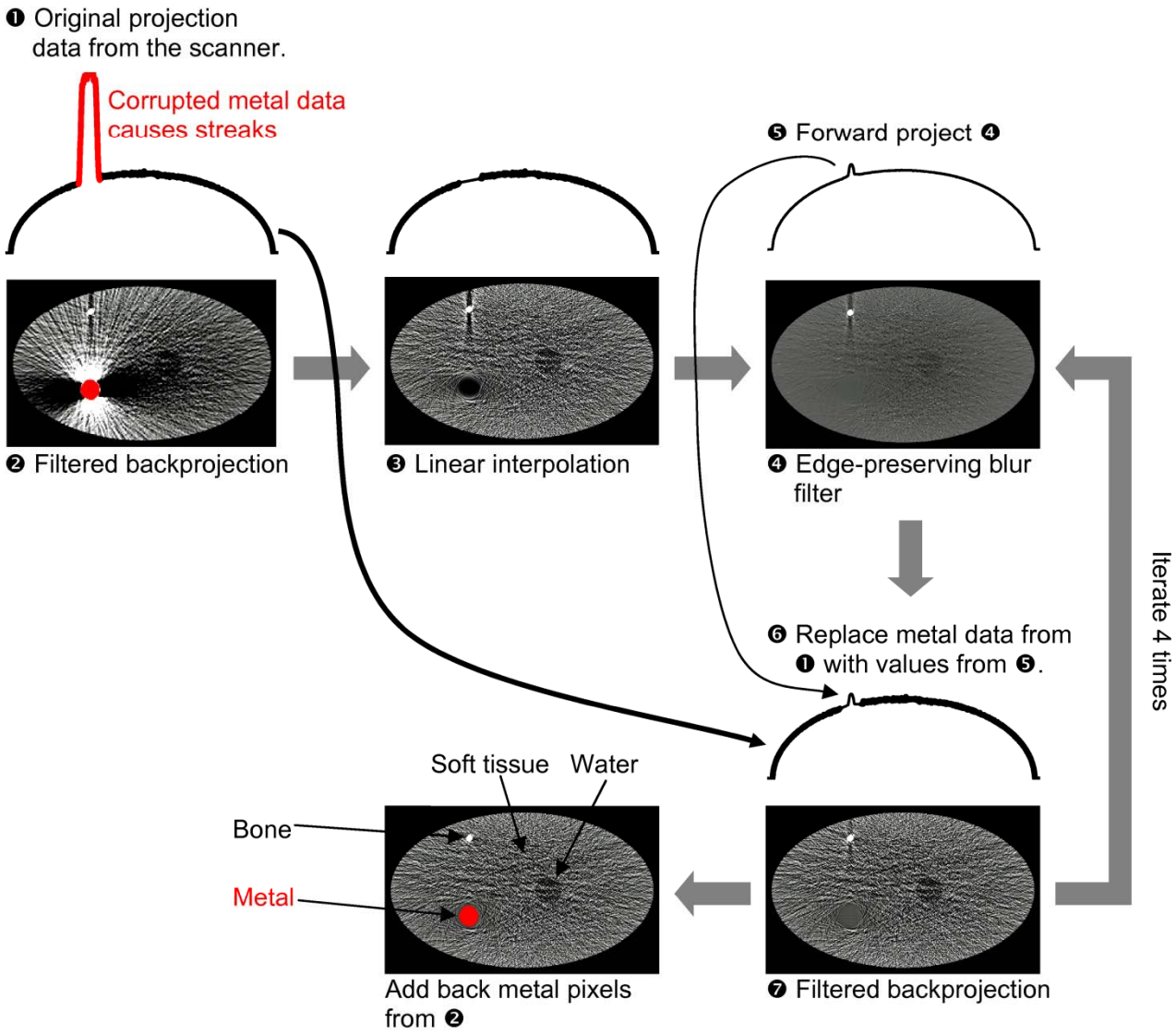
Boas FE and Fleischmann D. (2011) "Evaluation of two iterative techniques for reducing metal artifacts in computed tomography." *Radiology*. 259(3): 894-902.

Golden C, Mazin SR, Boas FE, Tye G, Ghanouni P, Gold G, Sofilos M, Pelc NJ. (2011) "A comparison of four algorithms for metal artifact reduction in CT imaging." *SPIE Medical Imaging Conference 2011*, Orlando, Florida.

Boas FE. (2011) "Iterative reduction of artifacts in computed tomography images using forward projection and an edge-preserving blur filter." U.S. Patent Application.

Further details

Metal deletion technique (MDT)



Adaptive detector element size