

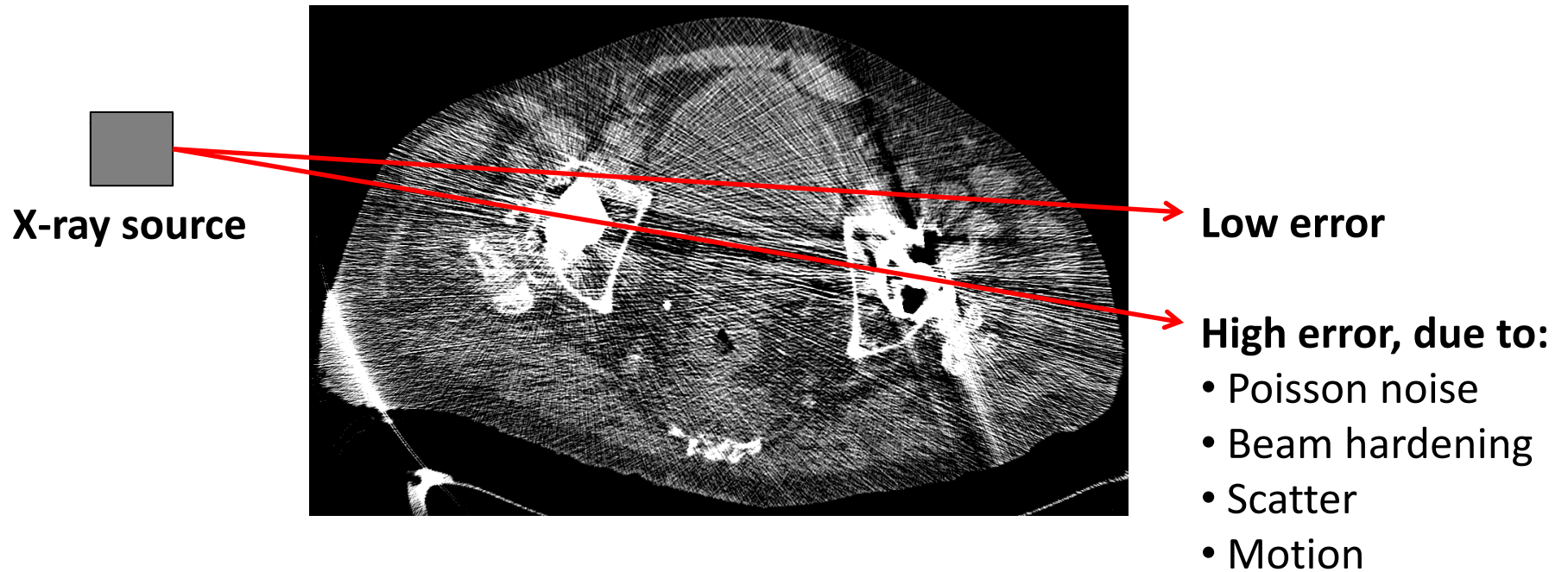
# CT metal artifact reduction using MDT

F. Edward Boas

<http://www.revisionrads.com>

2013-04-26

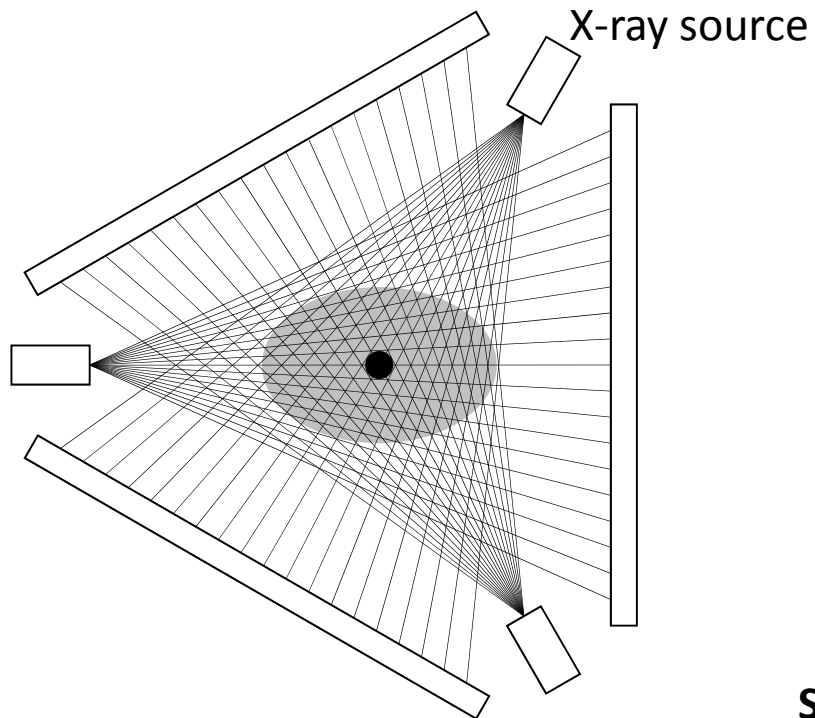
# CT metal artifacts



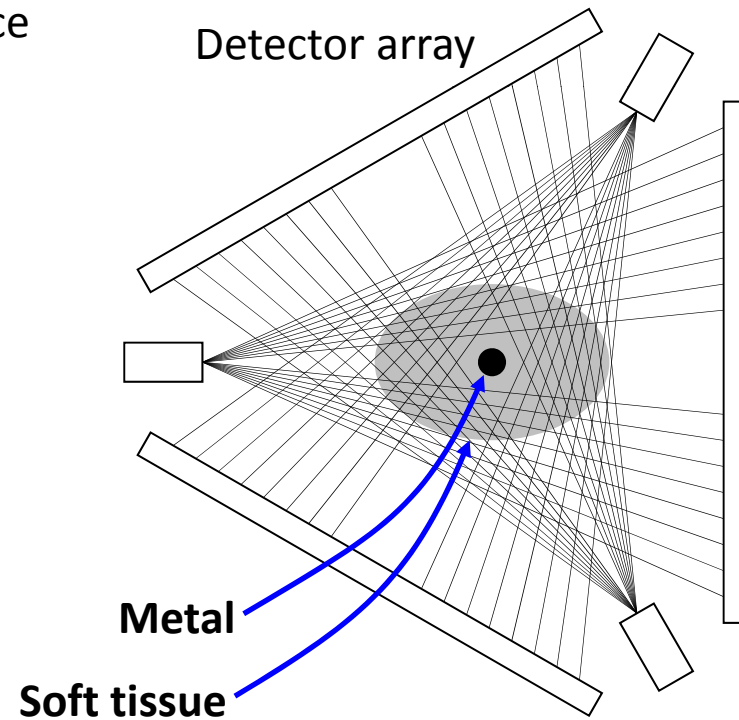
Dual energy CT only corrects for beam hardening.

# 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.



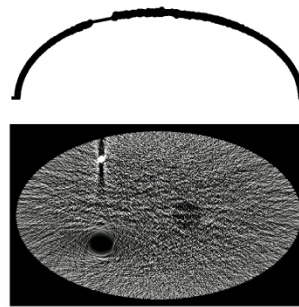
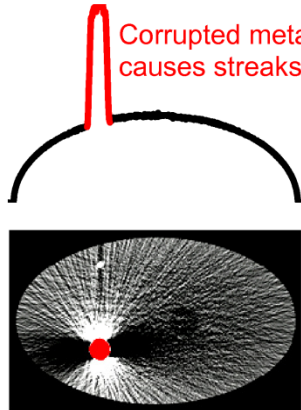
# Metal deletion technique (MDT)

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

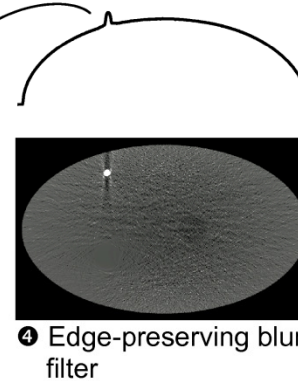
# Metal deletion technique (MDT)

❶ Original projection data from the scanner.

Corrupted metal data causes streaks

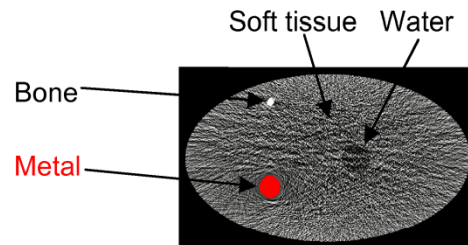


❺ Forward project ❹



❻ Replace metal data from ❶ with values from ❺.

Iterate 4 times



Add back metal pixels from ❷

# Cholecystectomy clips: FBP



# Cholecystectomy clips: LI



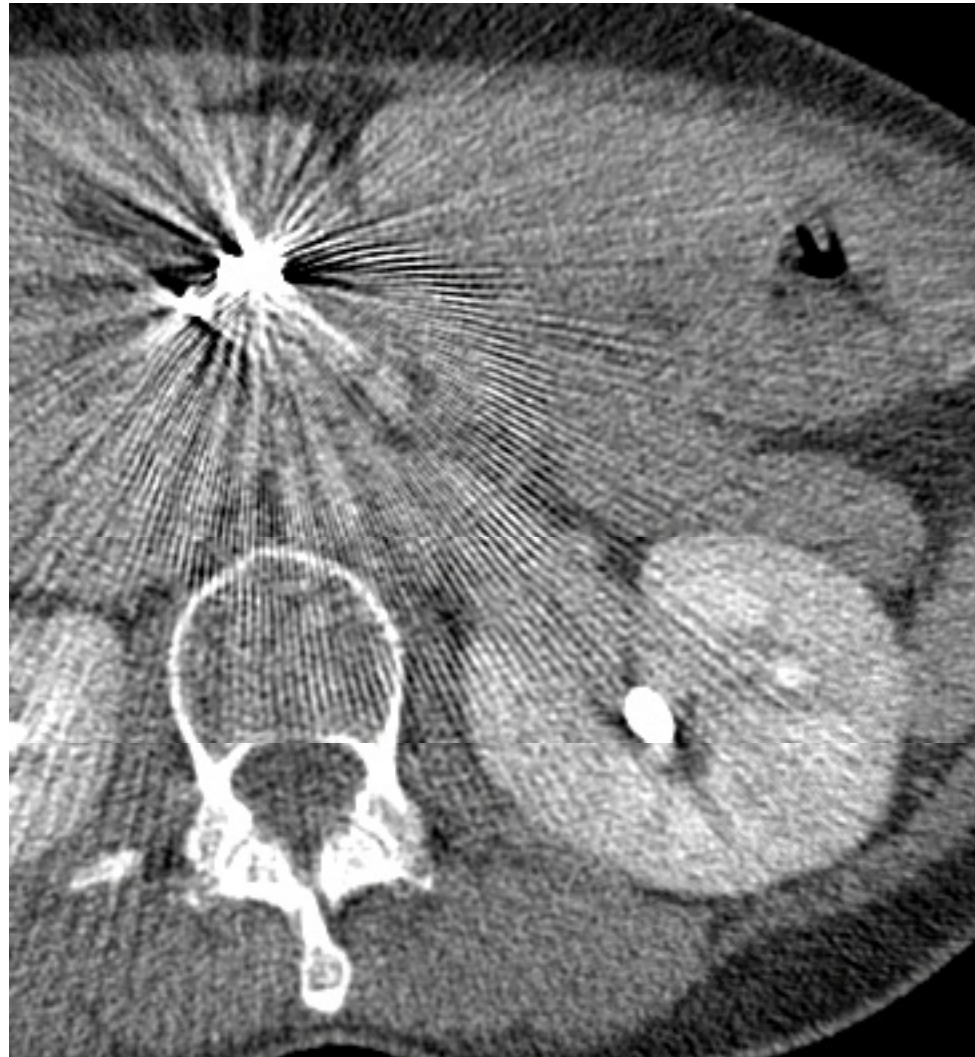


# Cholecystectomy clips: MDT





# Embolization coils: FBP



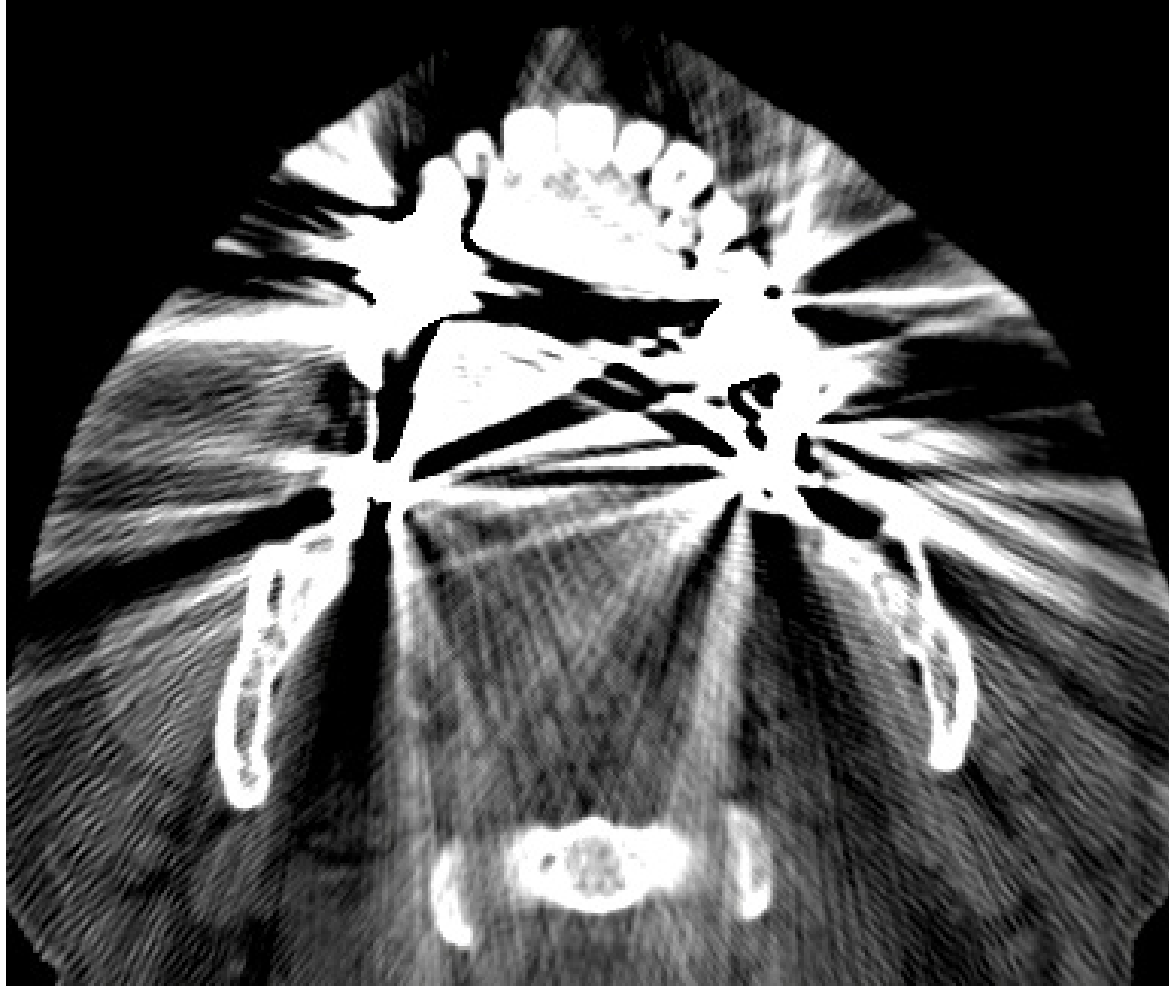
# Embolization coils: LI



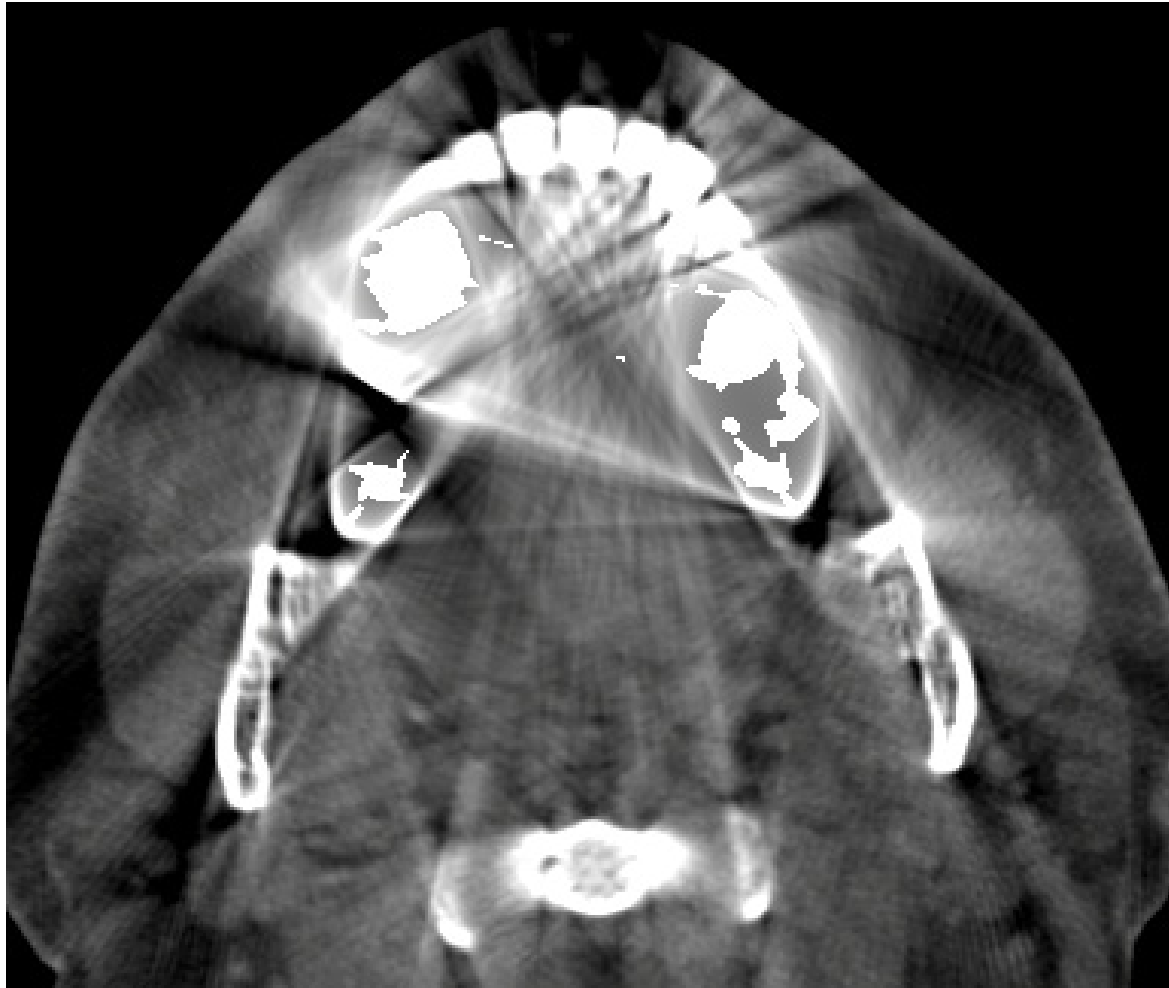
# Embolization coils: MDT



# Dental fillings: FBP



# Dental fillings: LI

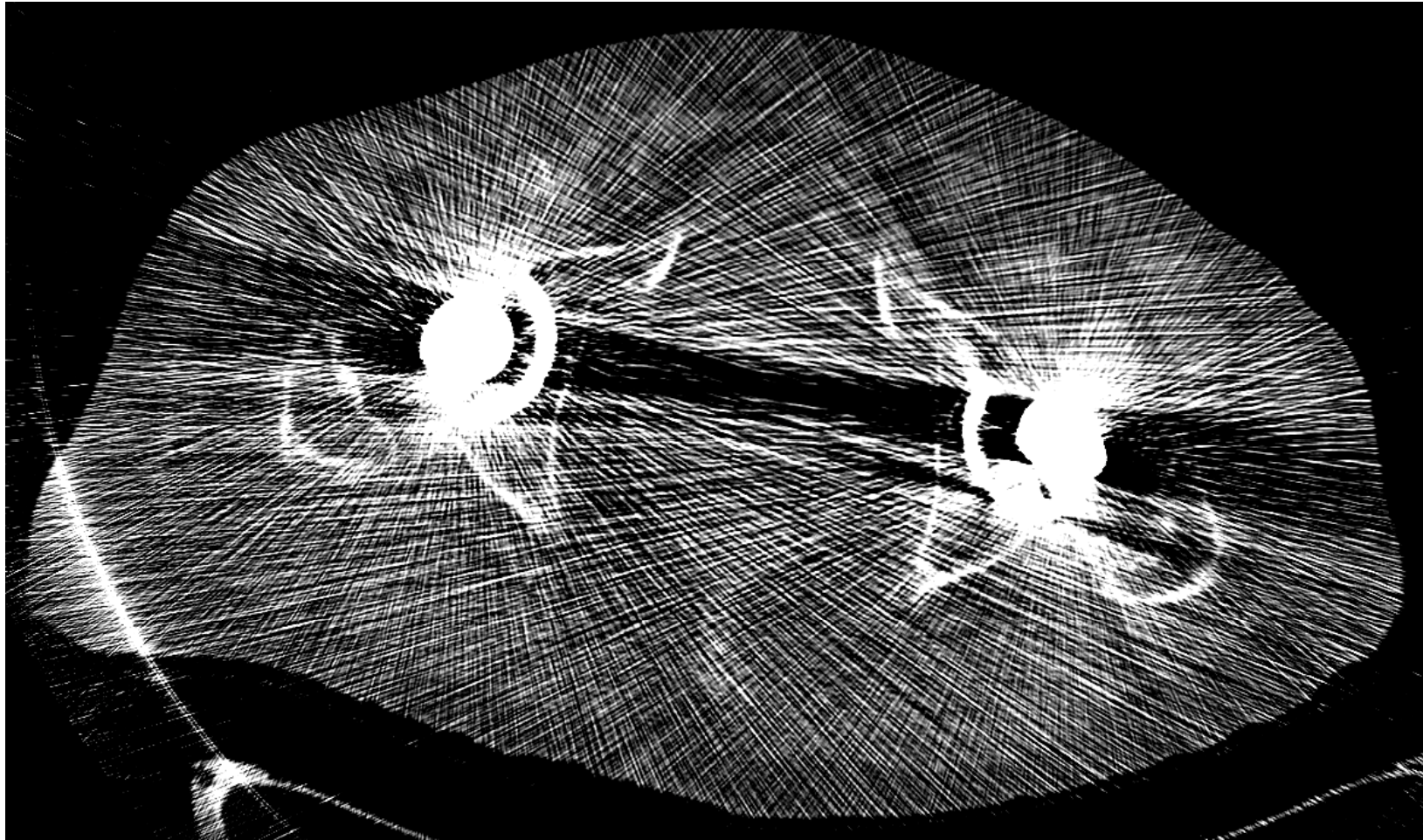


# Dental fillings: MDT

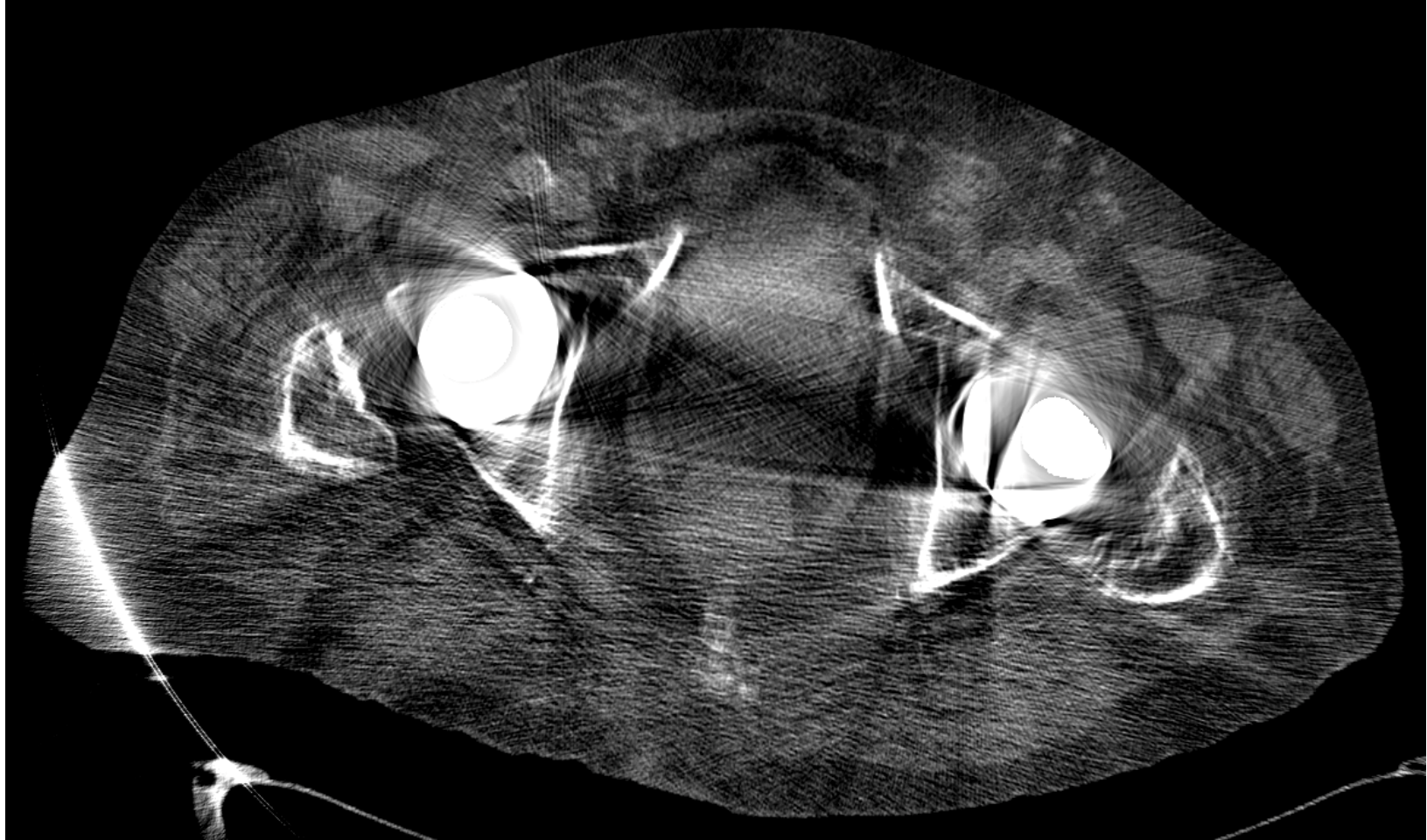




# Hip replacements: FBP

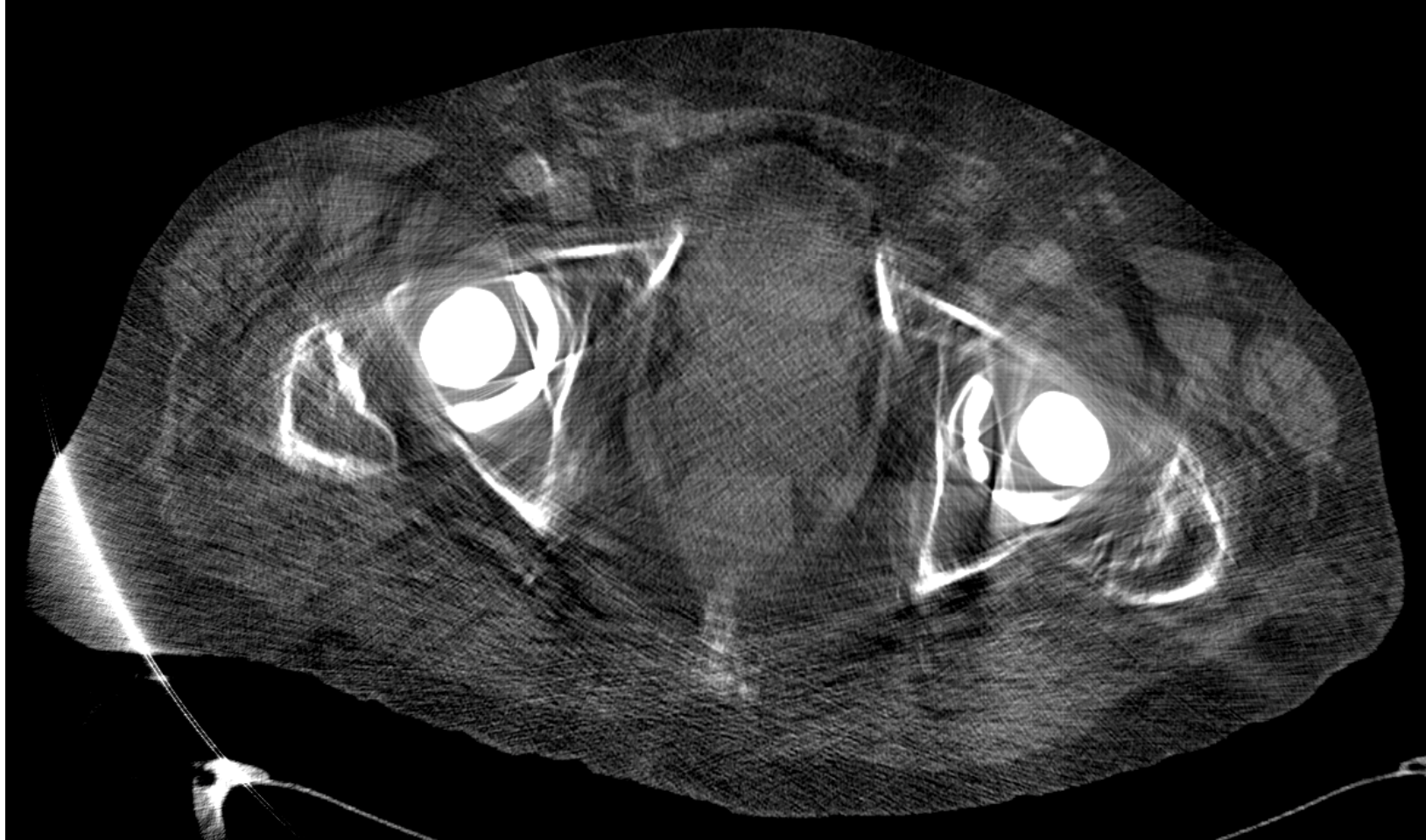


# Hip replacements: LI

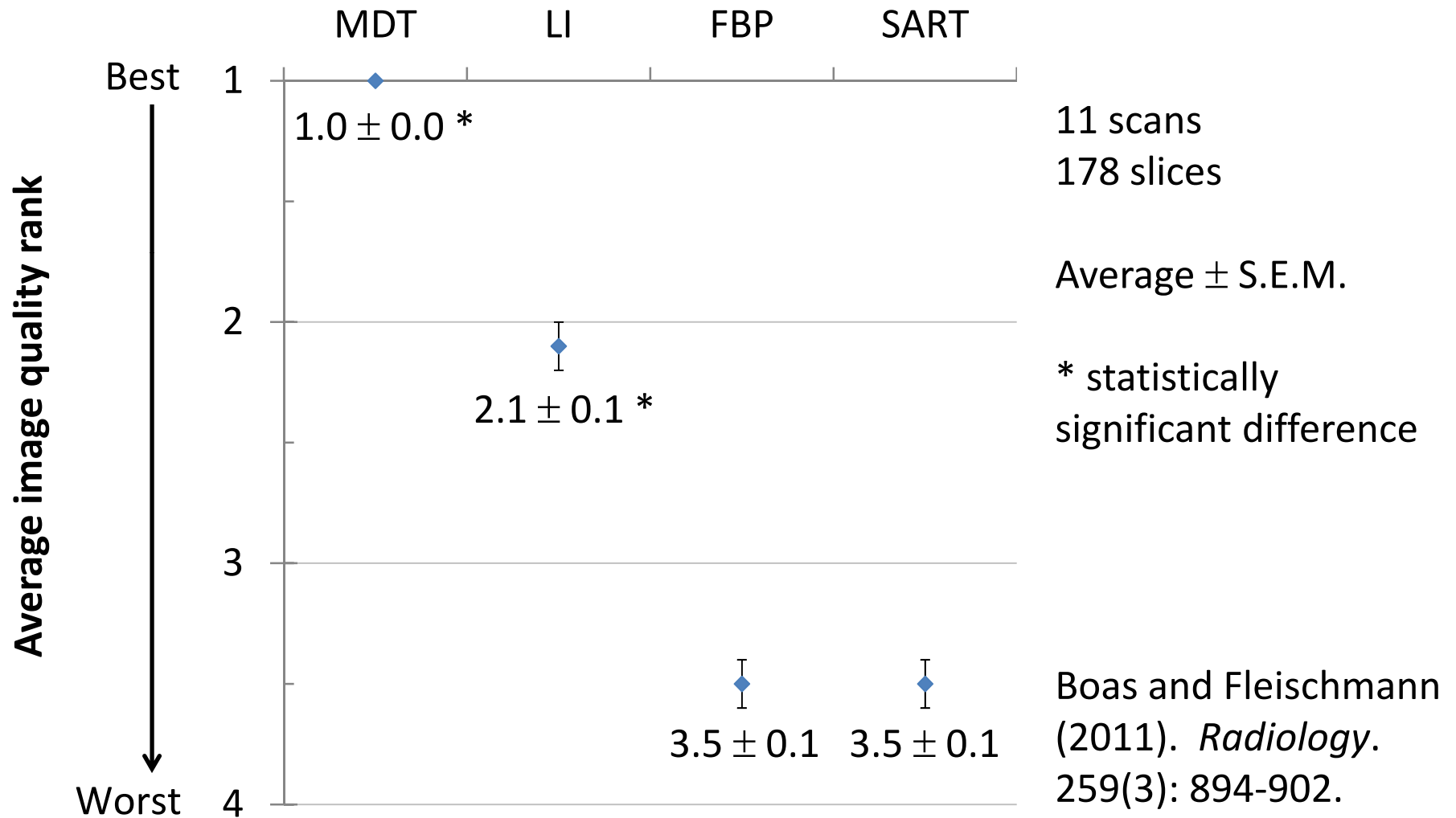




# Hip replacements: MDT



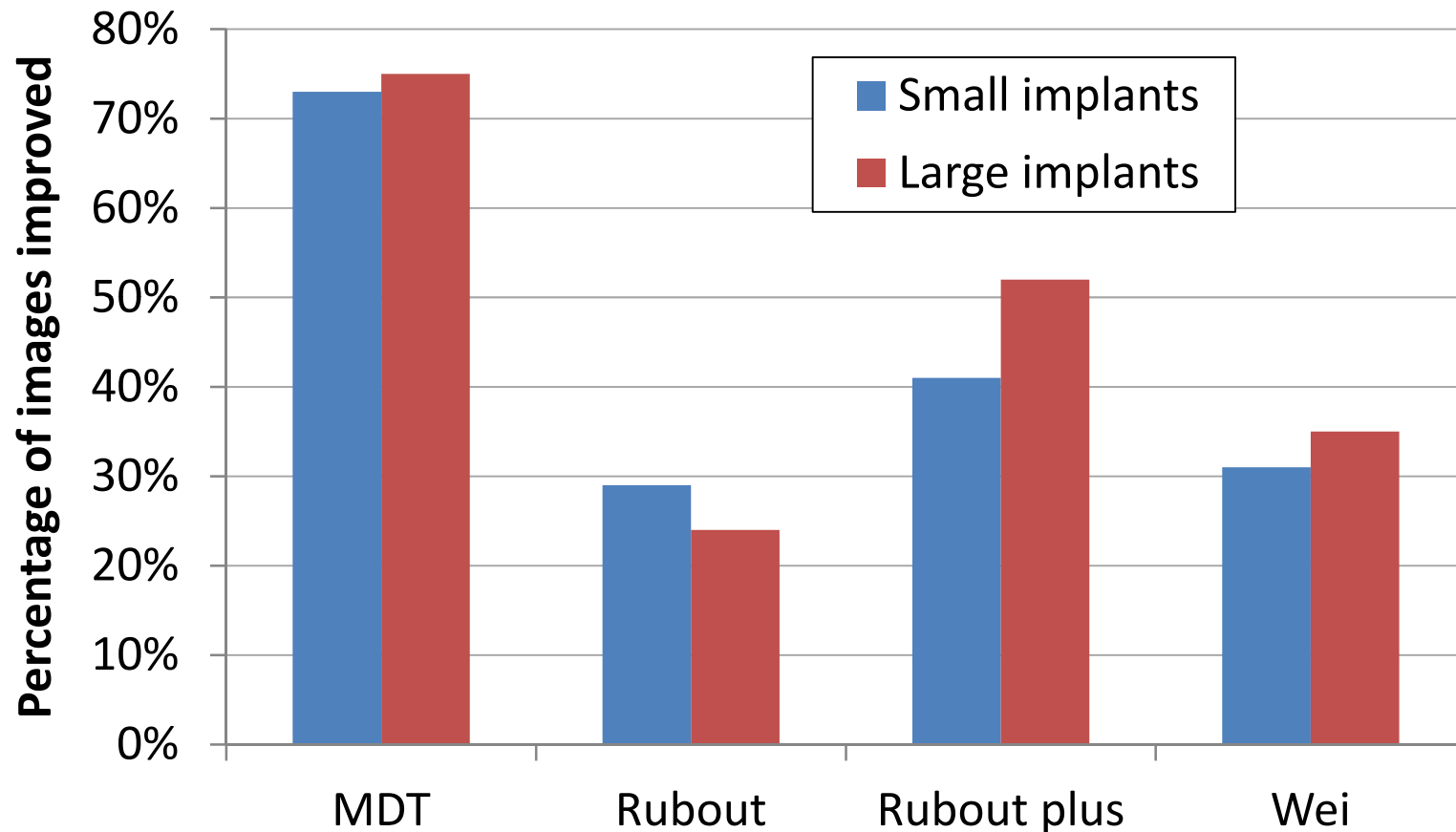
# Image quality rank (raw data)



# Metal artifact reduction from DICOM

If raw data are 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. *Proc. SPIE*. 7961: 79612Y

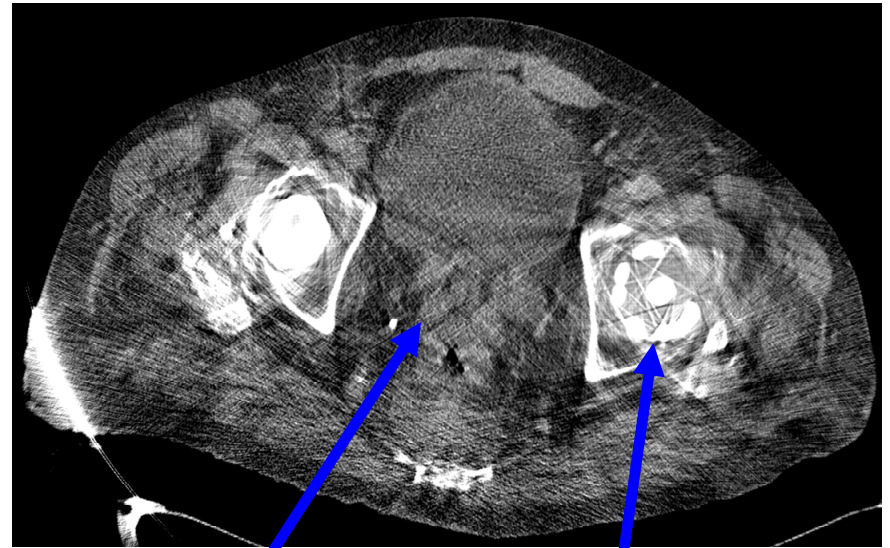


# Improved diagnosis

**FBP**



**MDT**

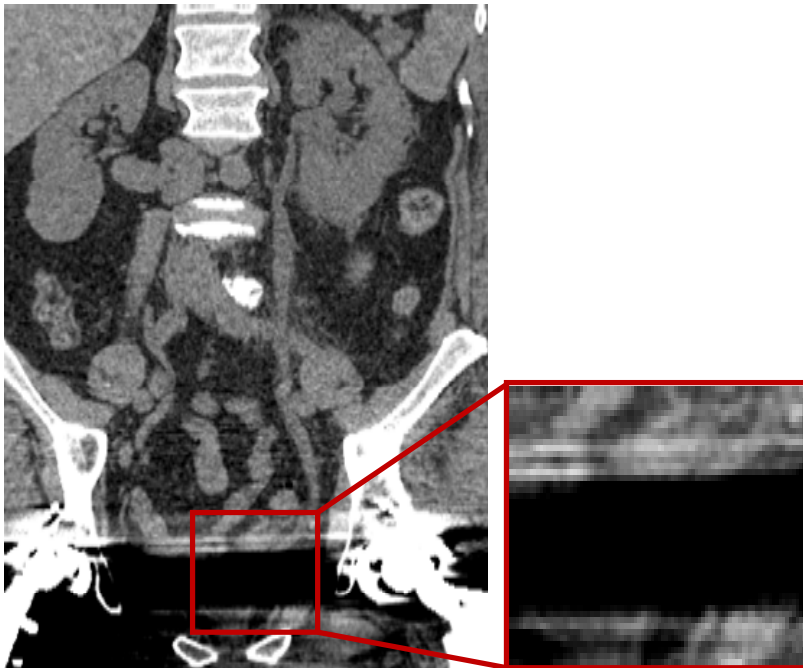


Rectal cancer

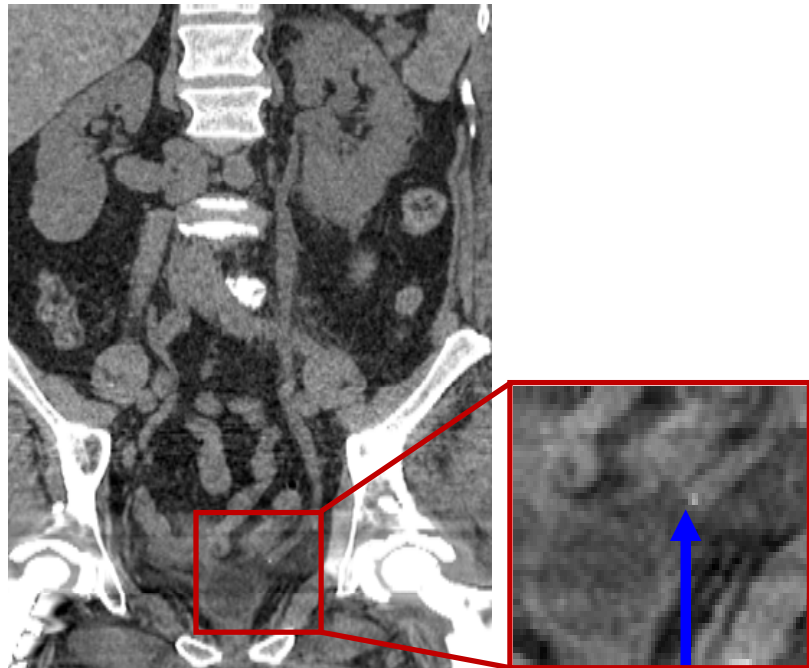
Hip replacement

# Improved diagnosis (DICOM)

**FBP**



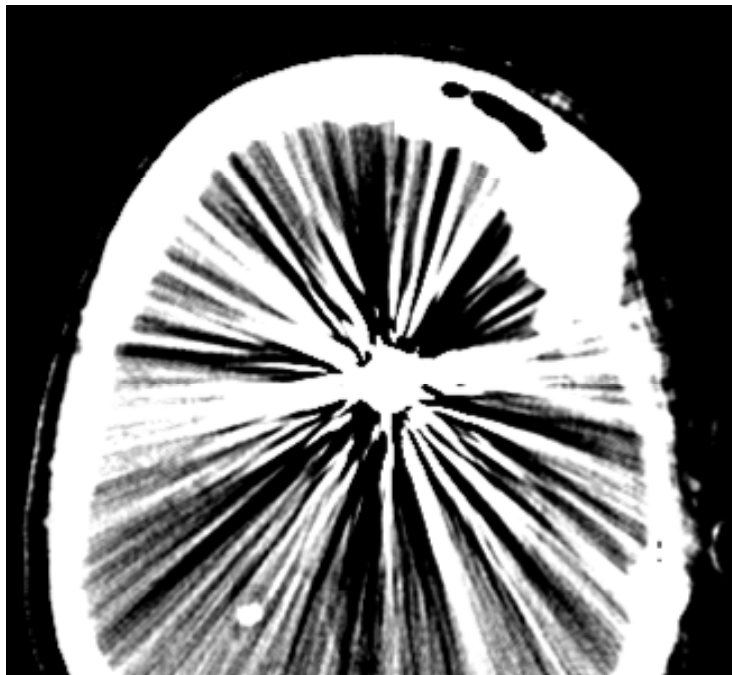
**MDT**



Obstructing stone

# Improved diagnosis (DICOM)

**FBP**



**MDT**



Infarct

Aneurysm coil

# Improved diagnosis (DICOM)

**FBP**



**MDT**



Coil

Hemorrhage

# Improved diagnosis (DICOM)

In 13 of 90 scans (14%), MDT changed the diagnosis, improved visualization of key findings, or improved diagnostic confidence.

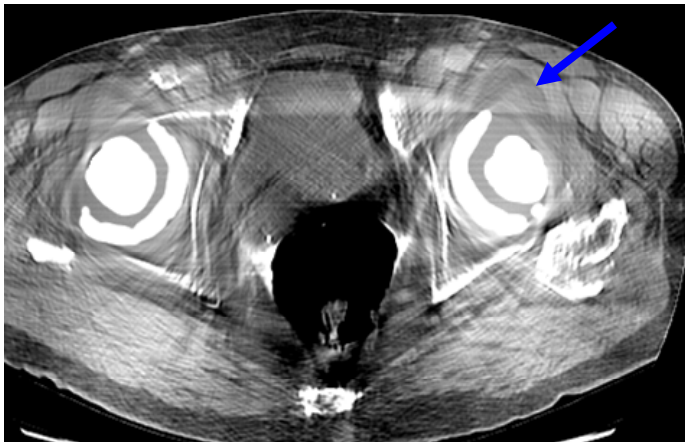
Result	Finding	Metal implant	# of cases
Changed diagnosis	Obstructing ureteral stone	Bilateral hip replacements	1
Improved vis.	Hemorrhage or infarct	Intracranial aneurysm coil or clip	6
Improved vis.	Pelvic mass	Bilateral hip replacements	1
Improved vis.	Periprosthetic fluid collection	Hip replacement	1
Improved vis.	Traumatic urethral injury	Bilateral hip hardware	1
Improved confidence	No parotid duct stone	Dental fillings	1
Improved confidence	No ureteral stone	Hip replacement	1
Improved confidence	No PE or mesenteric ischemia	Biventricular assist device	1

Boas FE, Bammer R, Fleischmann D. Presented at RSNA 2012.

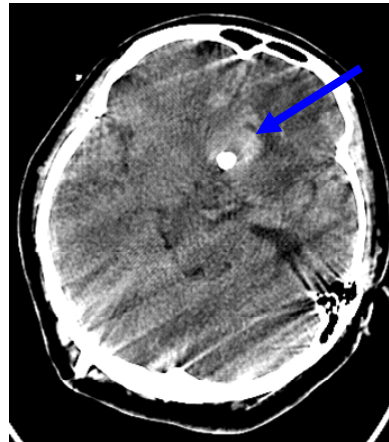
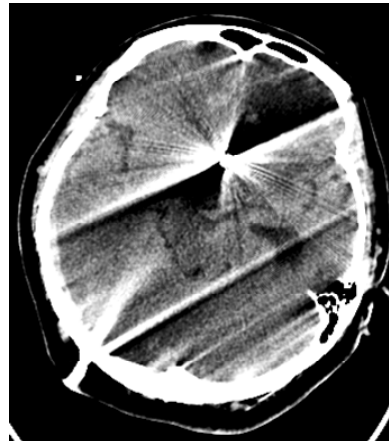


# MDT reduces metal artifacts caused by multiple different mechanisms

**Beam hardening and scatter**



**Motion and undersampling**



**Windmill**





# MDT performance by implant type

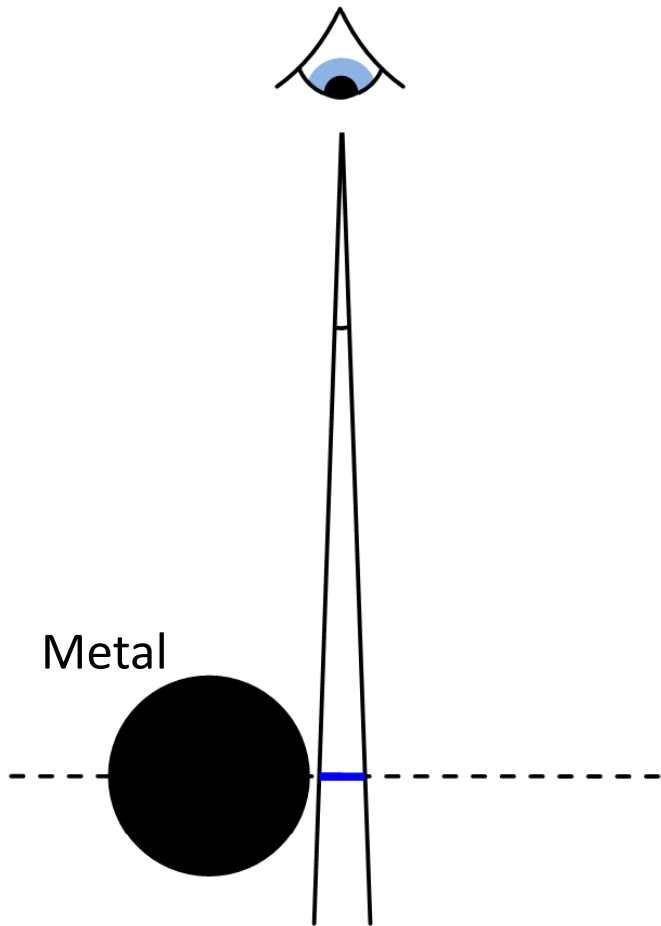
Improved in $\geq 75\%$ of cases		Improved in $< 75\%$ of cases
aneurysm clip (brain)	shoulder replacement	<b>pedicle screws</b>
aneurysm coil (brain)	hip replacement	depth electrodes (brain)
dental fillings	knee replacement	cryoablation probes
pacer wire	orthopedic plate(s)	iodinated contrast
ventricular assist device	<b>femoral neck screw</b>	
surgical clip(s)	spinal rods	
embolization coil(s)		
bullet(s) / schrapnel /		
lead shot		

Based on a review of 102 cases.

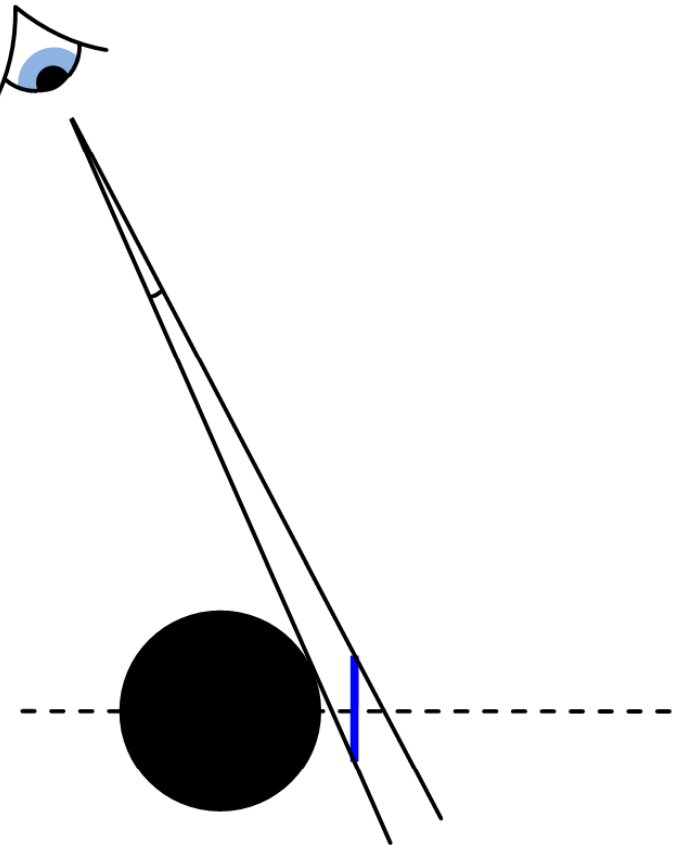
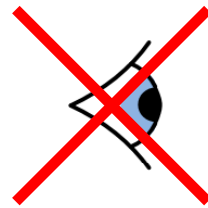
Boas and Fleischmann (2012). *Imaging in Medicine*. 4(2): 229-40.

# Decreased resolution near metal

Horizontal resolution

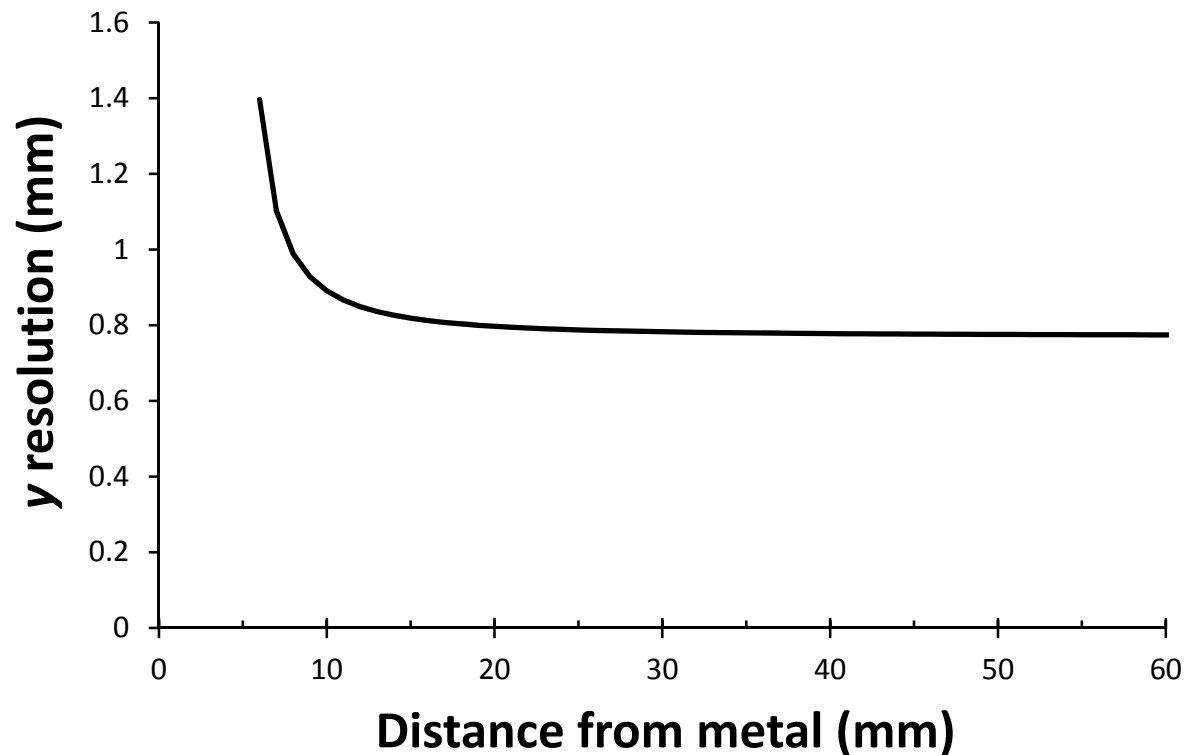


Vertical resolution

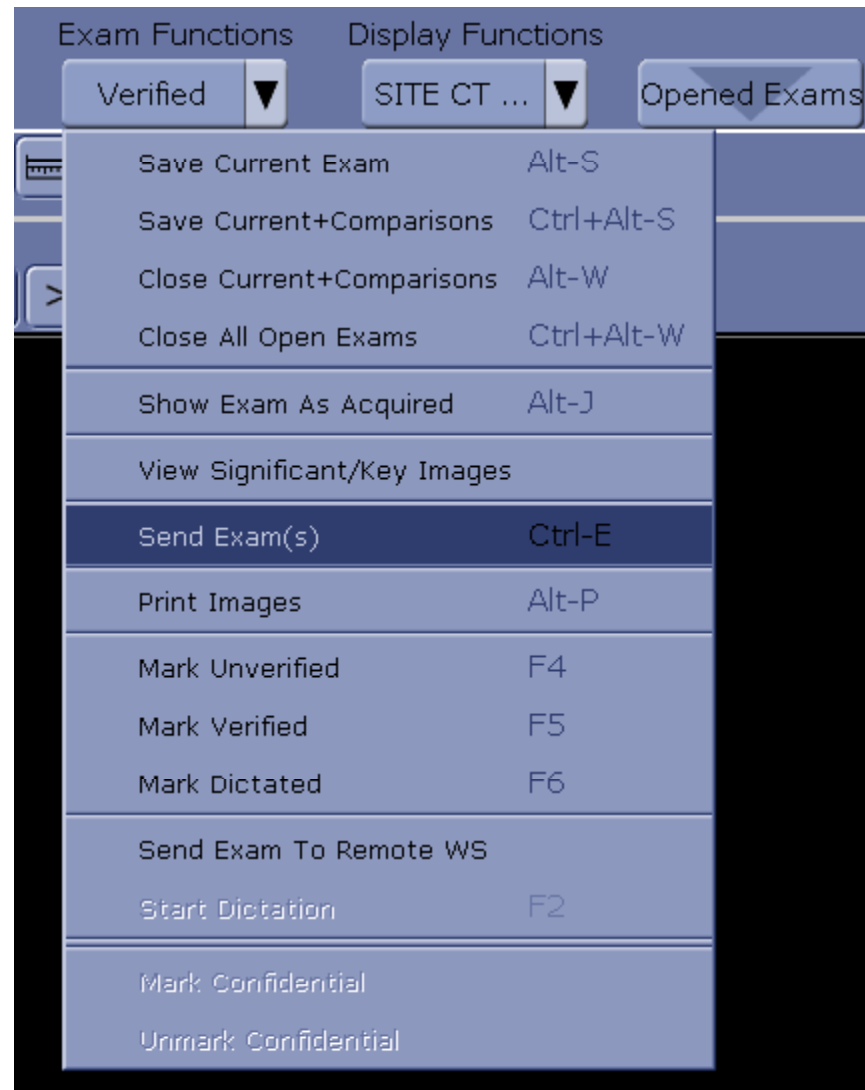


# Decreased resolution near metal

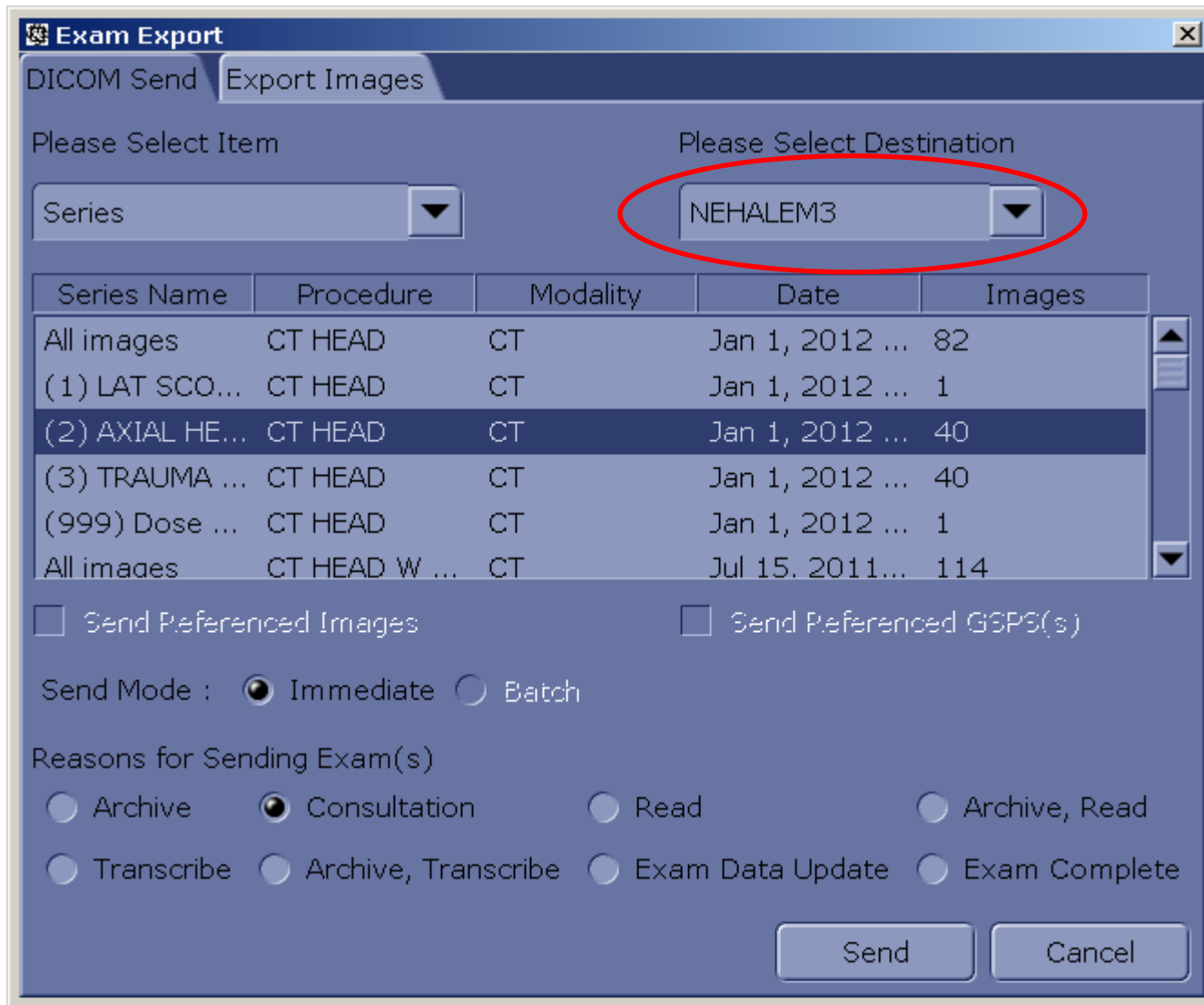
Resolution near a 10 mm metal implant



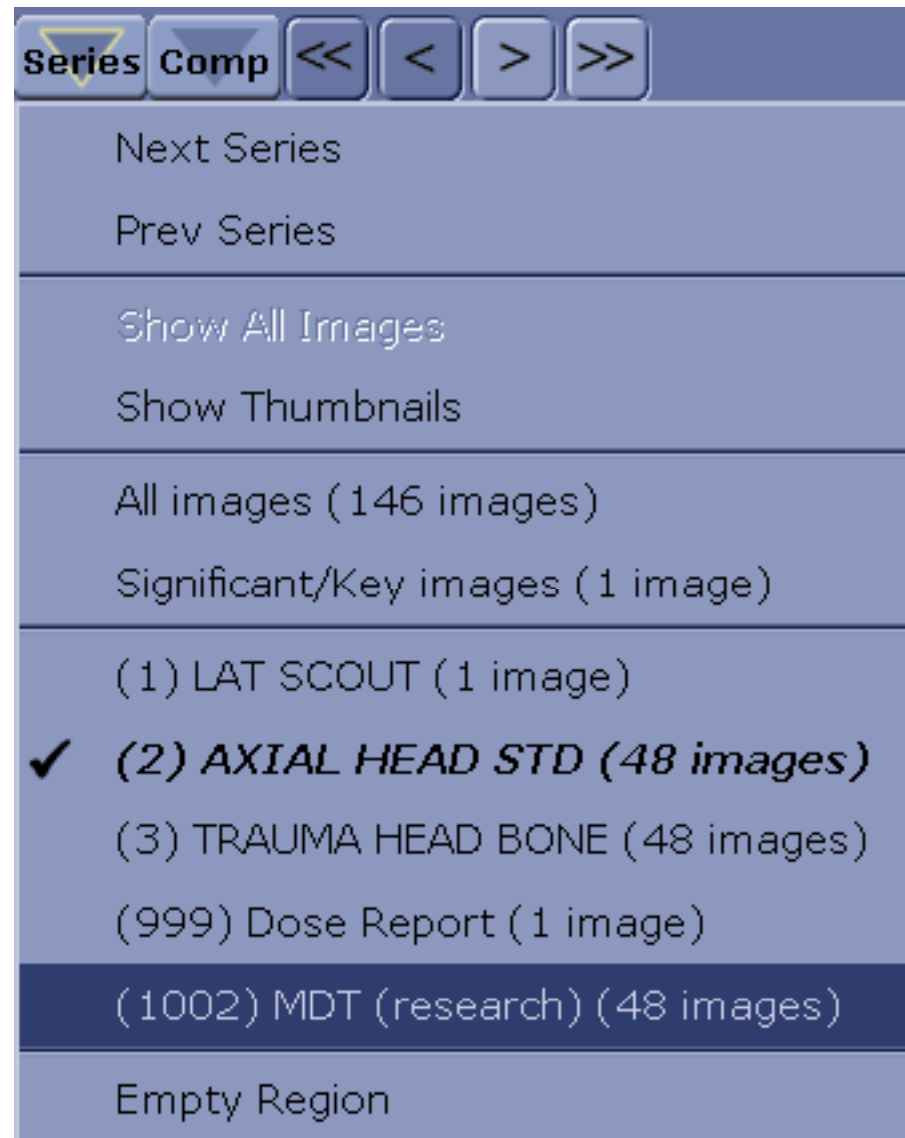
# Integration with PACS



# Integration with PACS



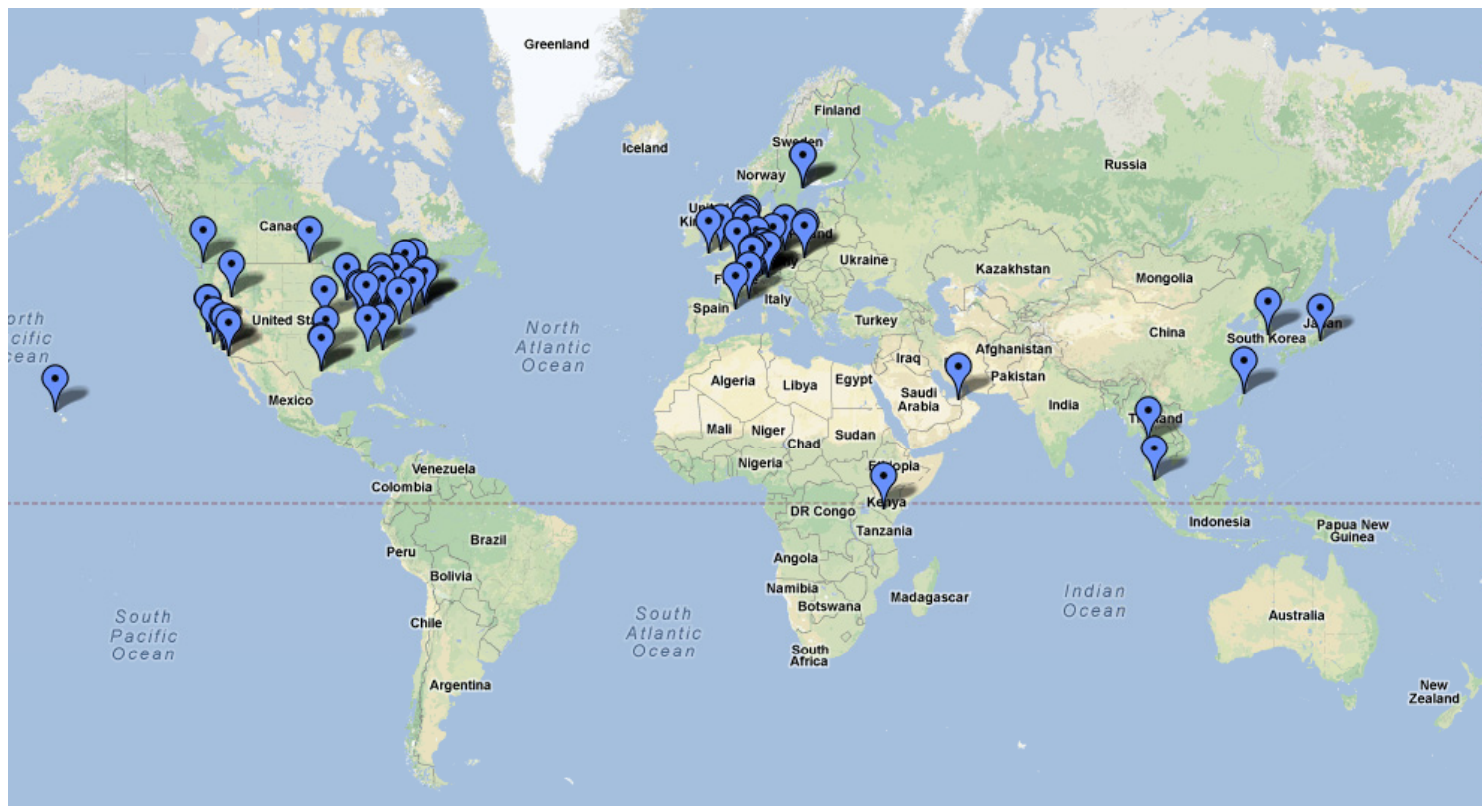
# Integration with PACS





# Clinical use of MDT

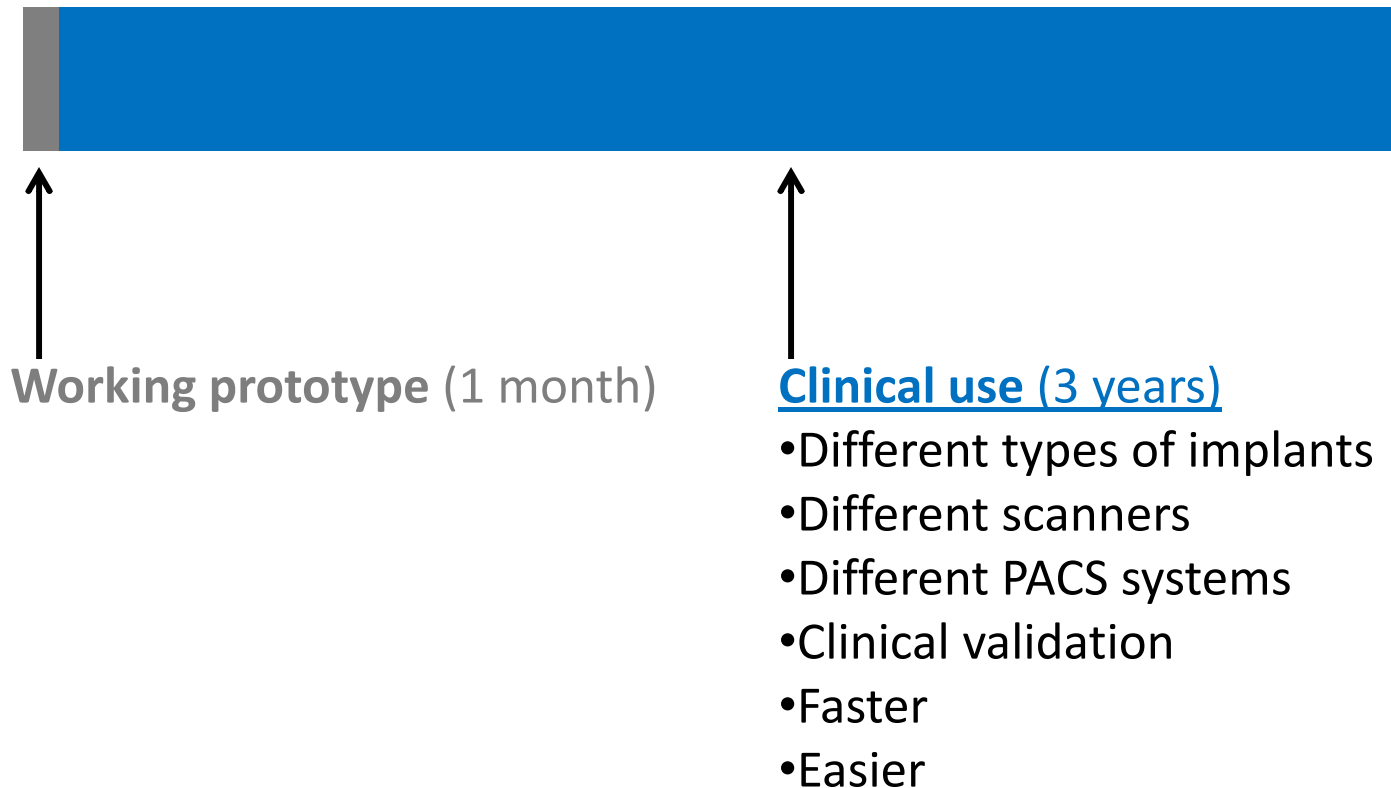
- 457 cases at Stanford
- 70 hospitals, of which 30 have licensed MDT for local use



# Conclusions

1. MDT reduces metal artifacts due to Poisson noise, beam hardening, and motion.
2. MDT has better image quality than other techniques ( $p=0.0005$ ).
3. In 14% of cases, MDT changed the diagnosis, improved visualization of key findings, or improved diagnostic confidence.

# MDT development timeline



# Acknowledgements

**Dominik Fleischmann**

Roland Bammer

Caroline Golden

Sam Mazin

Norbert Pelc

Jon Abelson

Chris Beaulieu

Peji Ghanouni

Grace Tye

RC Barbero (GE)

Rick Kong

Christoph Panknin (Siemens)