

CT metal artifact reduction using MDT



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Financial disclosures: None.


Note: Non-FDA approved software will be discussed.

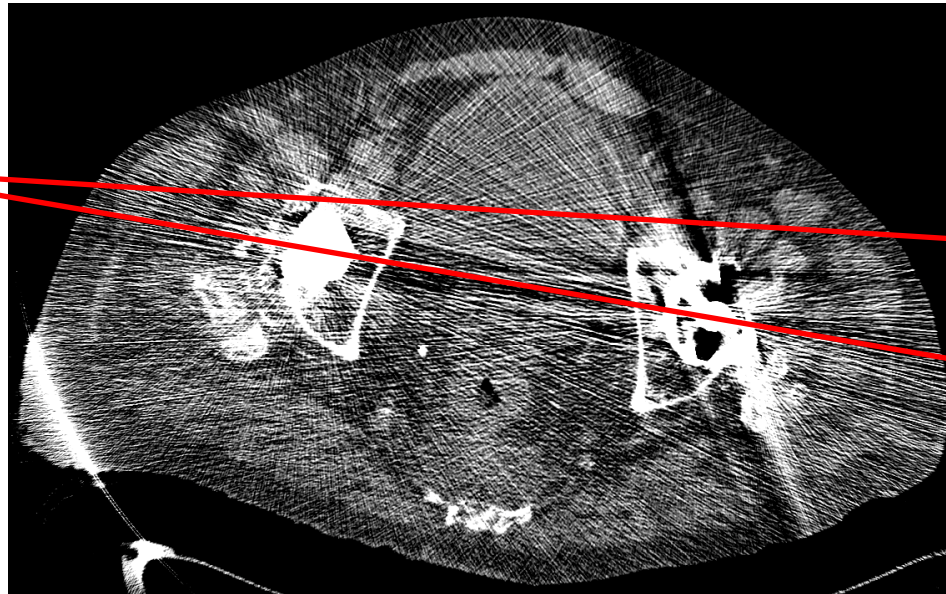
RSNA, 2012-11-26

CT metal artifacts



CT metal artifacts


X-ray source



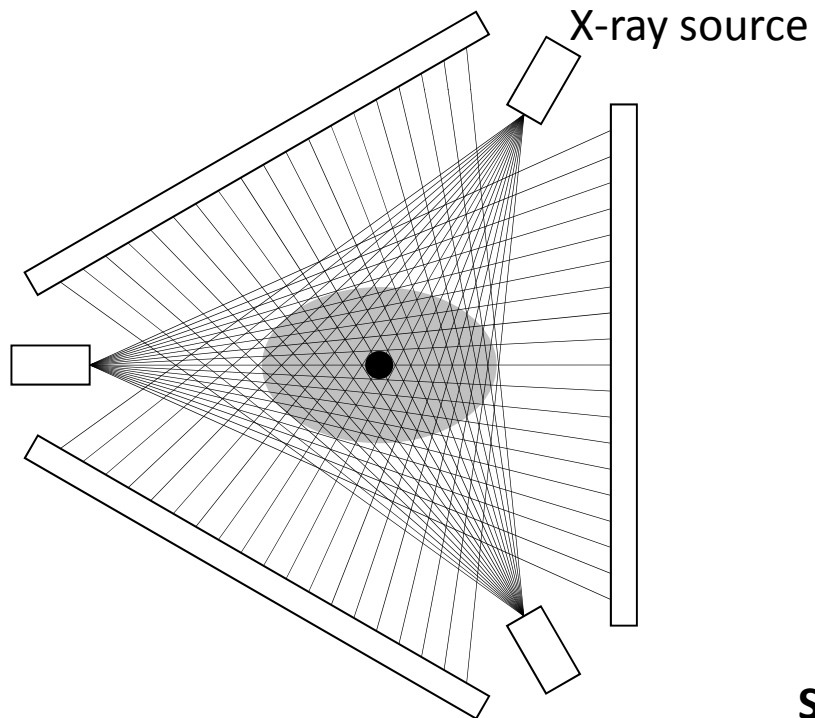
Low error

High error, due to:

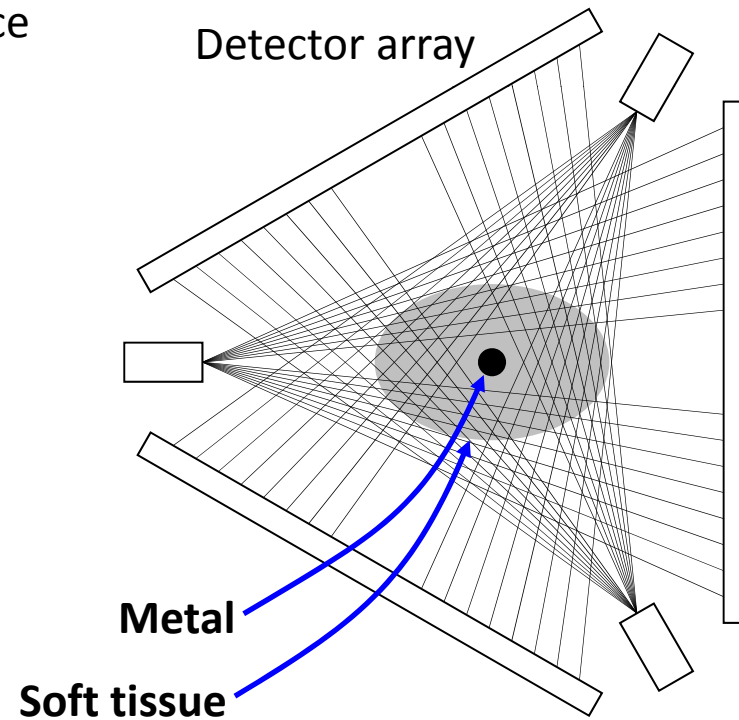
- Poisson noise
- Beam hardening
- Scatter
- Motion

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.

MDT reduces metal artifacts

FBP



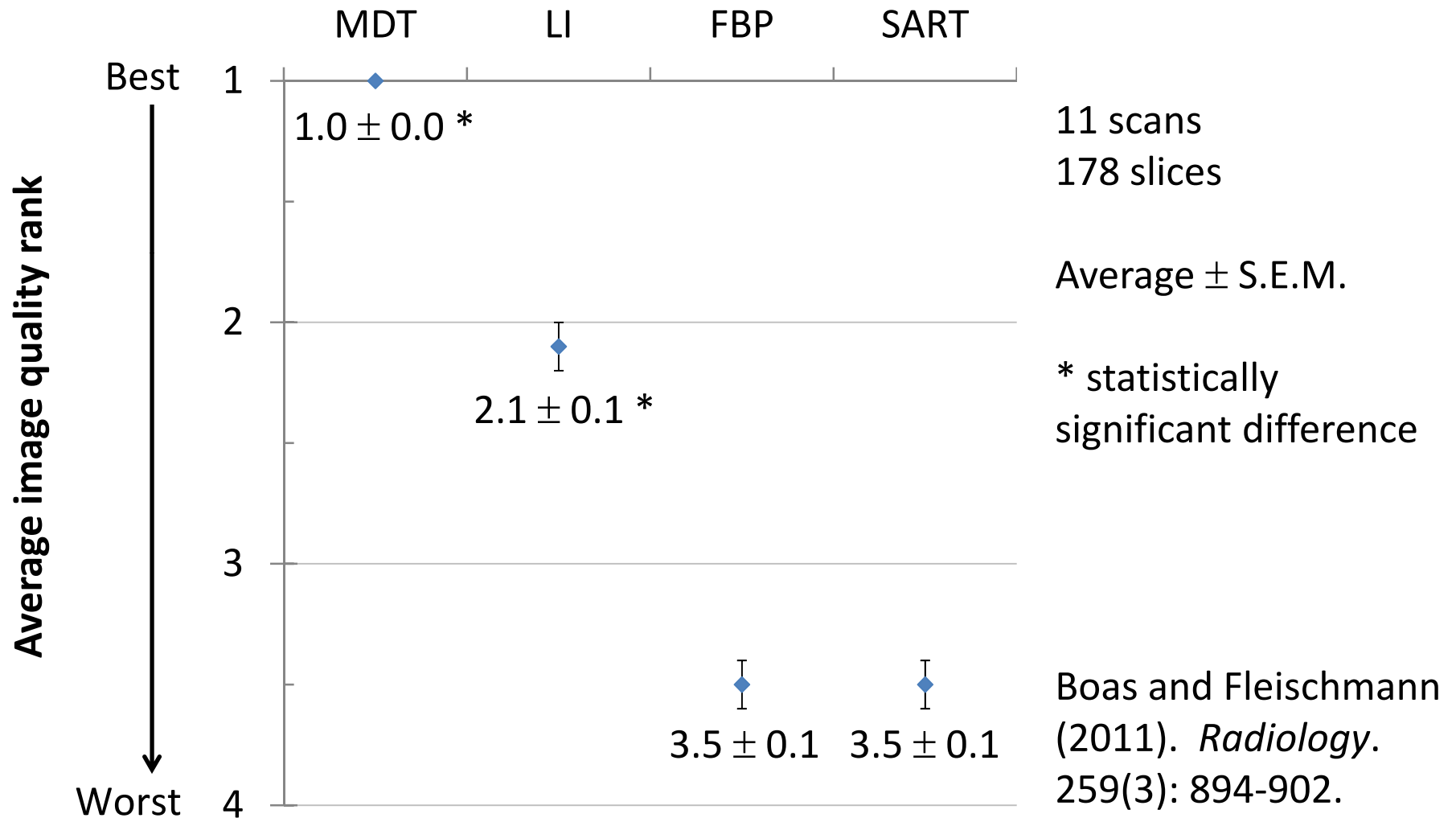
LI



MDT



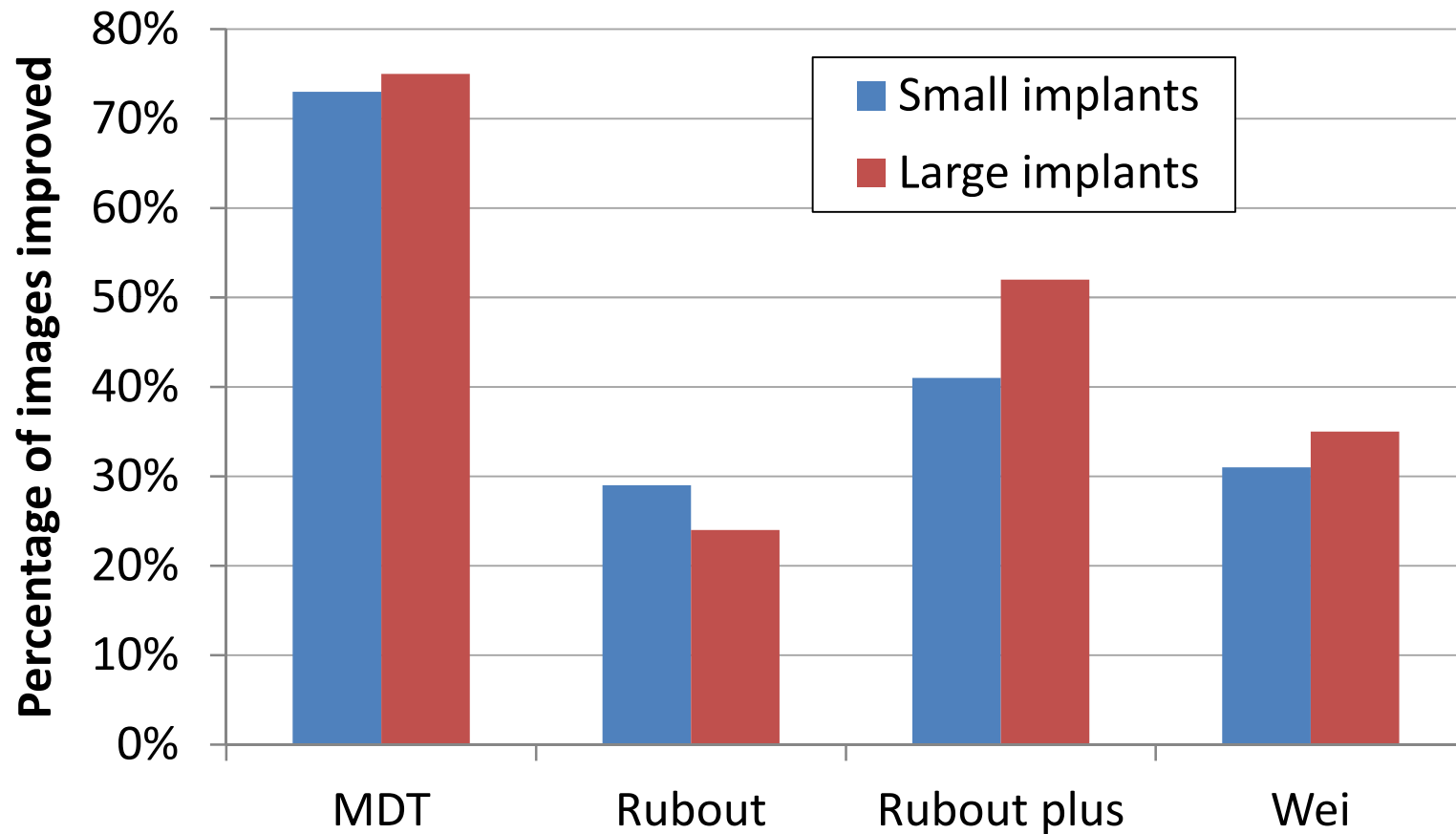
Image quality rank (raw data)



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)



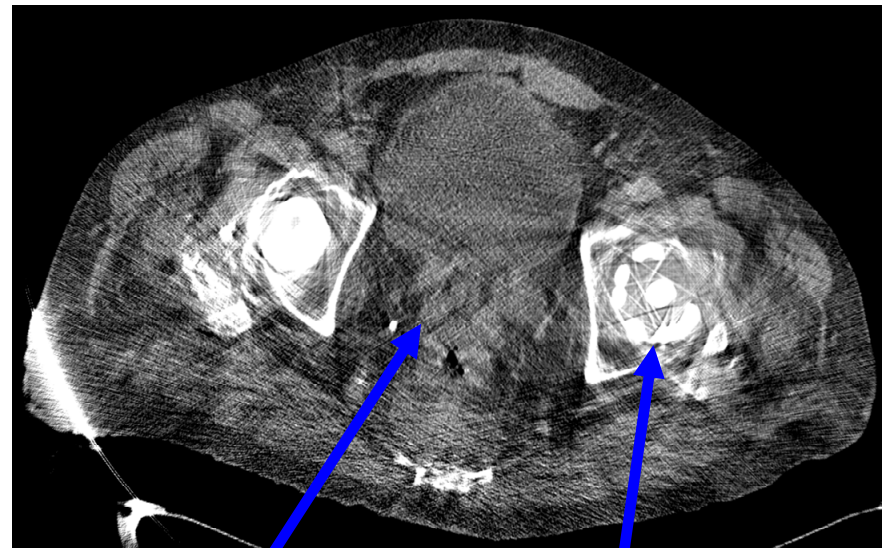
80 slices. Data from Caroline Golden, Sam Mazin, et al. *Proc. SPIE*. 7961: 79612Y

Improved diagnosis

FBP



MDT

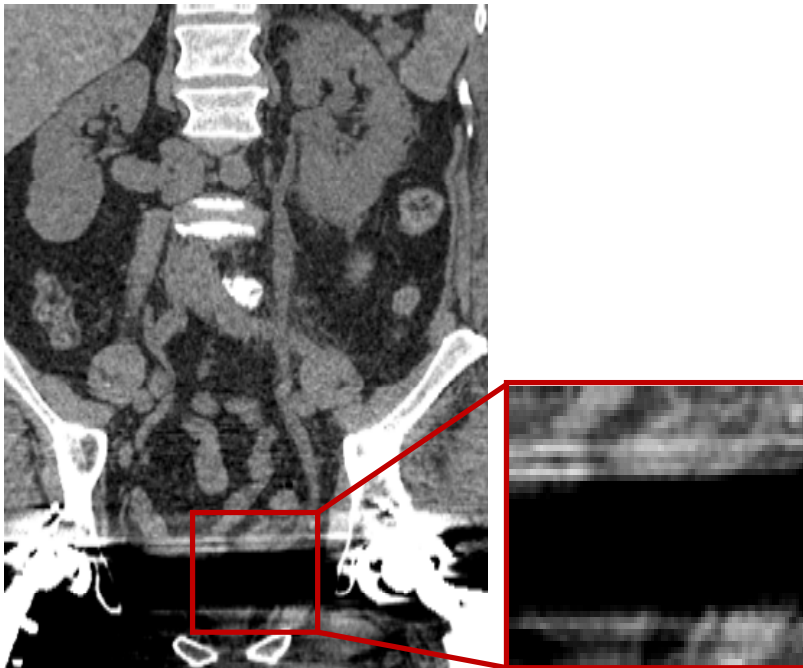


Rectal cancer

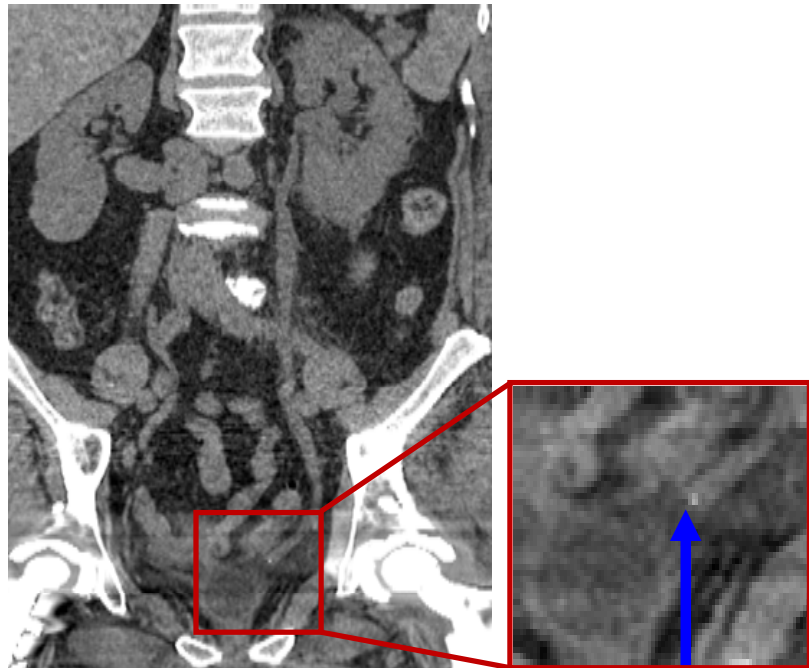
Hip replacement

Improved diagnosis (DICOM)

FBP



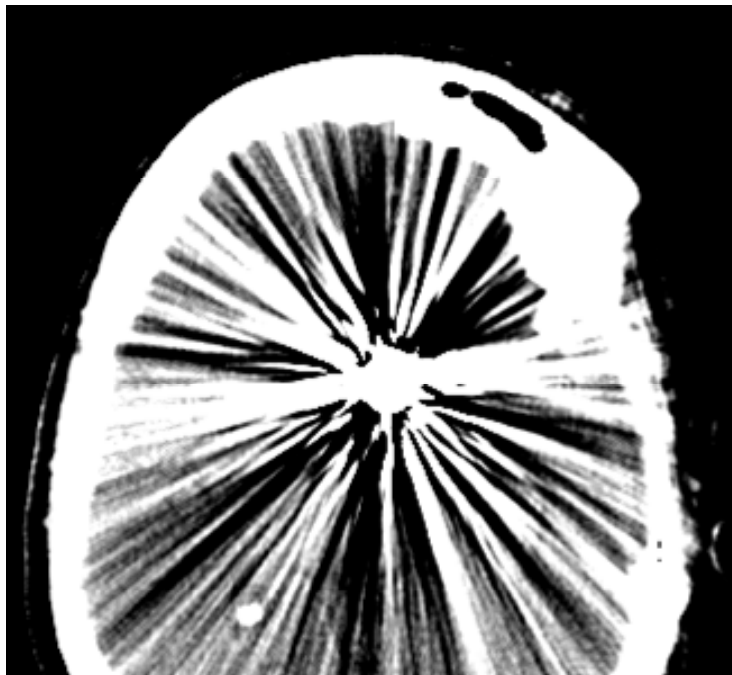
MDT



Obstructing stone

Improved diagnosis (DICOM)

FBP



MDT



Infarct

Aneurysm coil

Improved diagnosis (DICOM)

FBP



MDT



Coil

Hemorrhage

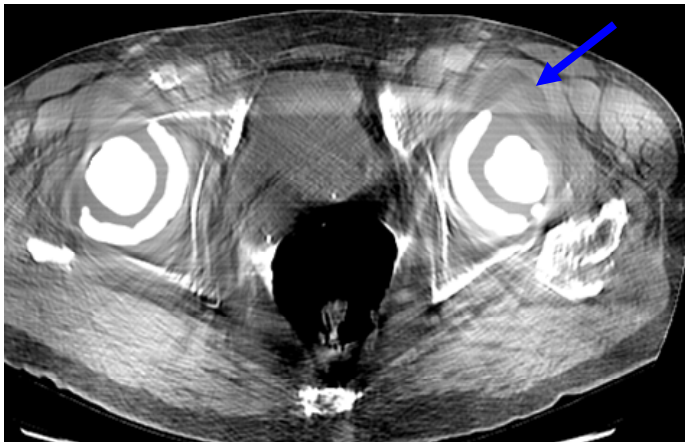
Improved diagnosis (DICOM)

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

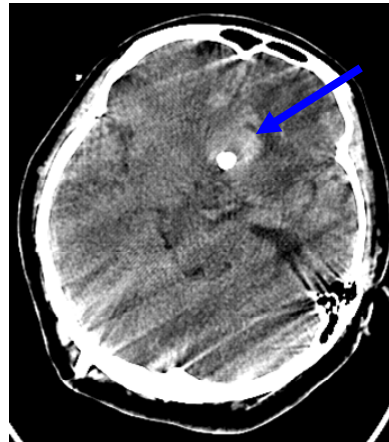
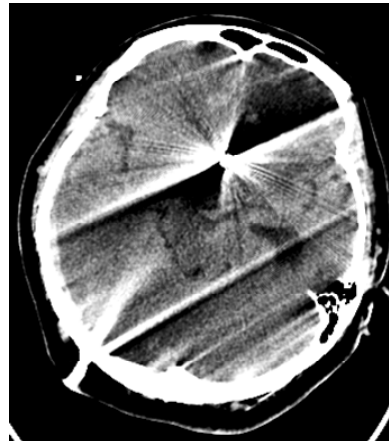
Result	Finding	Metal implant	# of cases
Changed diagnosis	Obstructing ureteral stone	Bilateral hip replacements	1
Improved vis.	Hemorrhage or infarct	Intracranial aneurysm coil or clip	6
Improved vis.	Pelvic mass	Bilateral hip replacements	1
Improved vis.	Periprosthetic fluid collection	Hip replacement	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

MDT reduces metal artifacts caused by multiple different mechanisms

Beam hardening and scatter



Motion and undersampling



Windmill



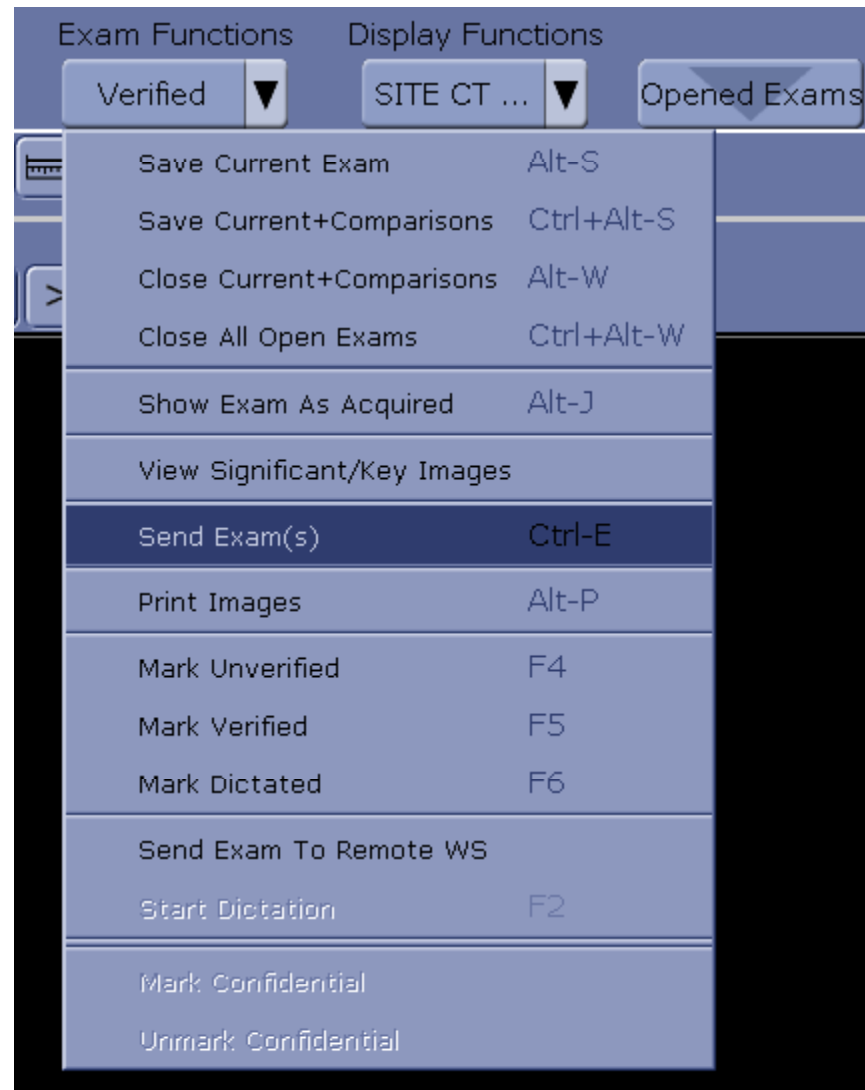
MDT performance by implant type

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

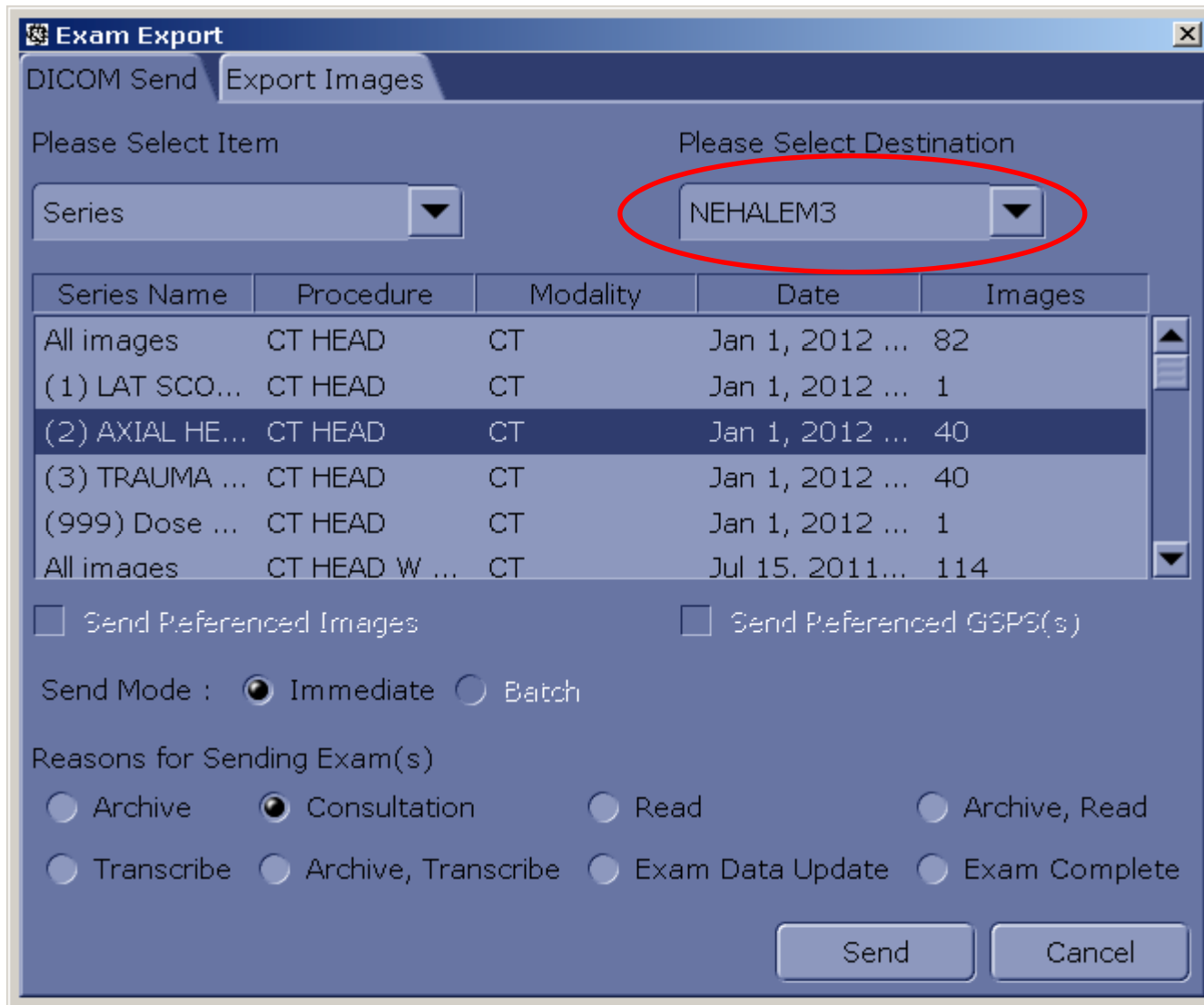
Based on a review of 102 cases.

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

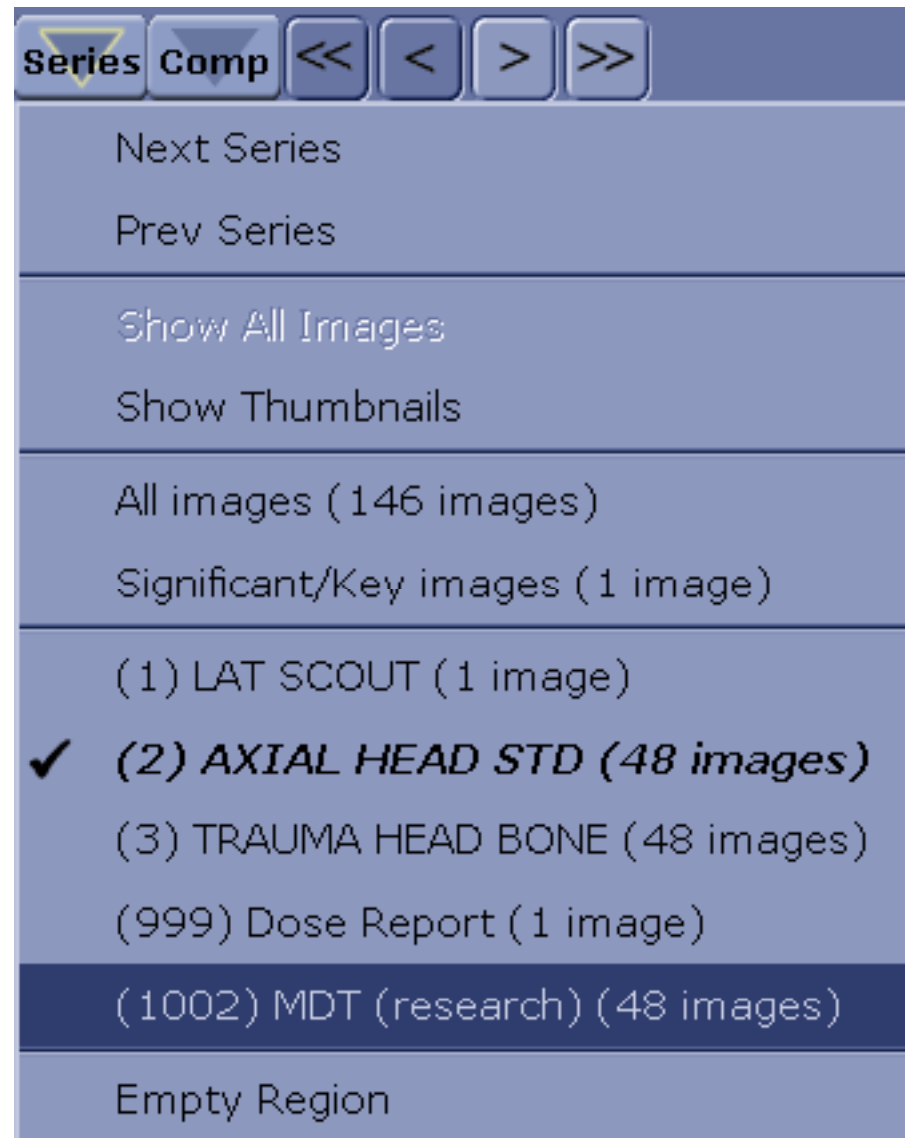
Integration with PACS



Integration with PACS

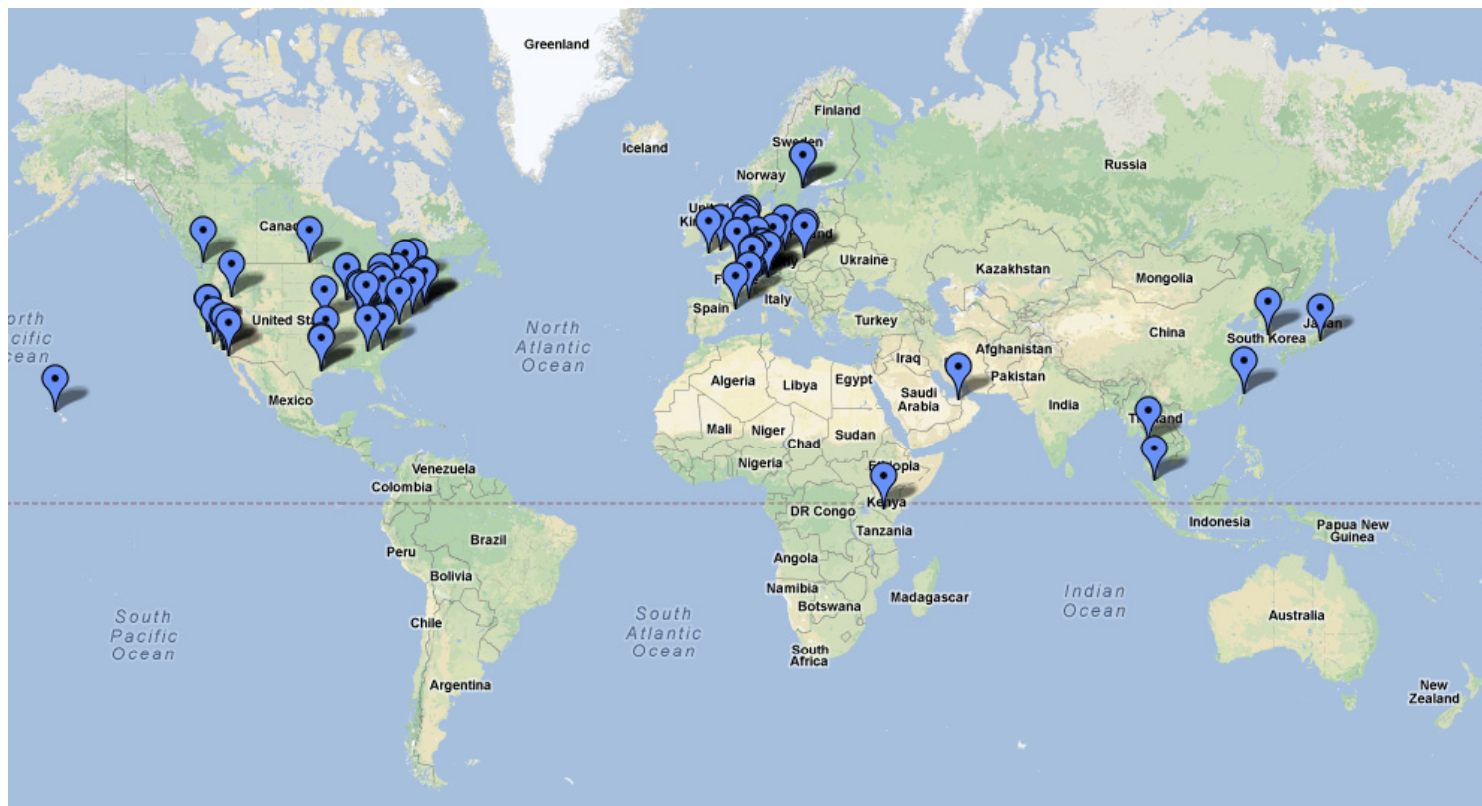


Integration with PACS



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.

Acknowledgements

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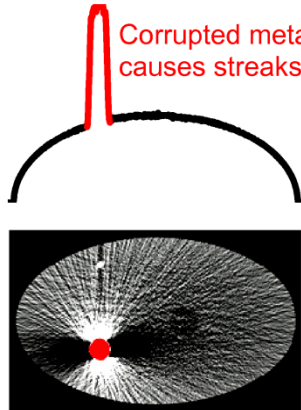
Rick Kong

Christoph Panknin (Siemens)

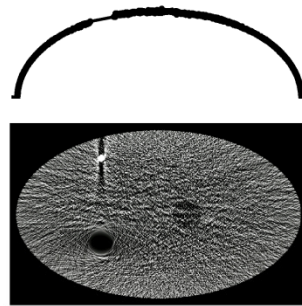
Metal deletion technique (MDT)

❶ Original projection data from the scanner.

Corrupted metal data causes streaks

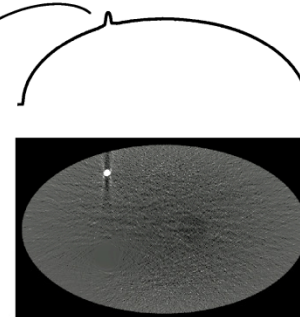


❷ Filtered backprojection



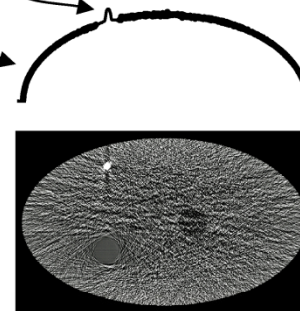
❸ Linear interpolation

❺ Forward project ❹

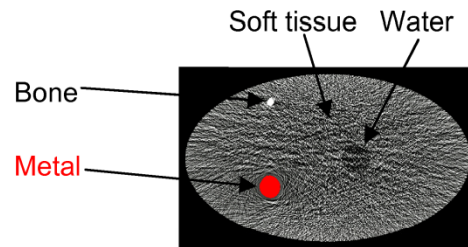


❹ Edge-preserving blur filter

❻ Replace metal data from ❶ with values from ❺.



Iterate 4 times

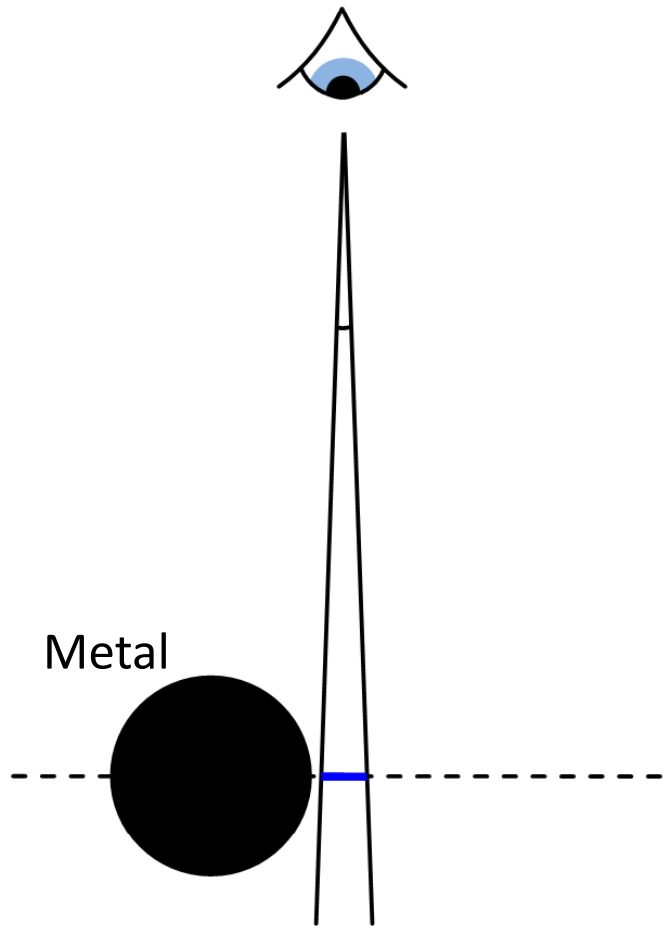


Add back metal pixels from ❷

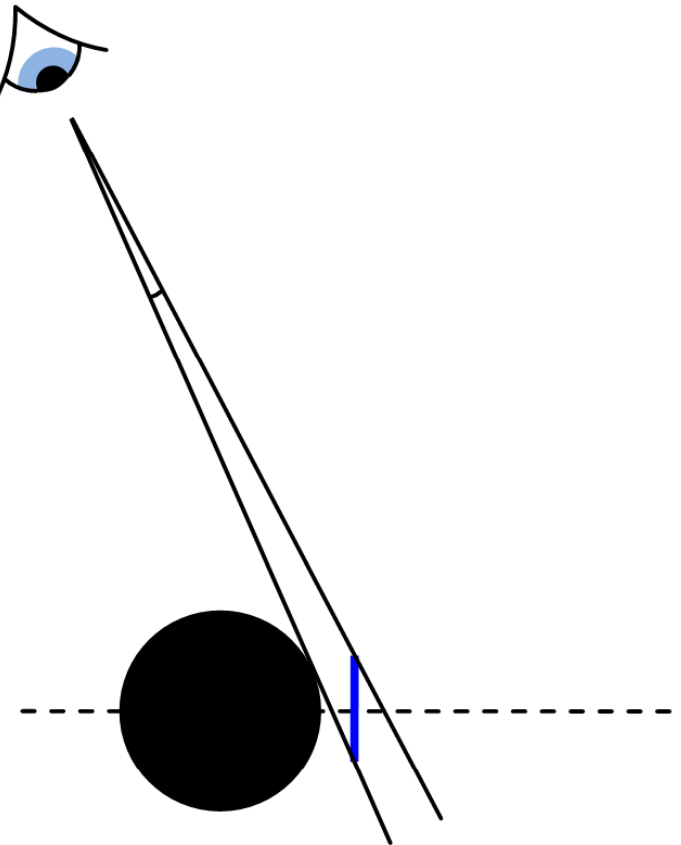
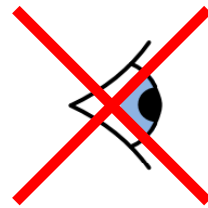
❼ Filtered backprojection

Decreased resolution near metal

Horizontal resolution

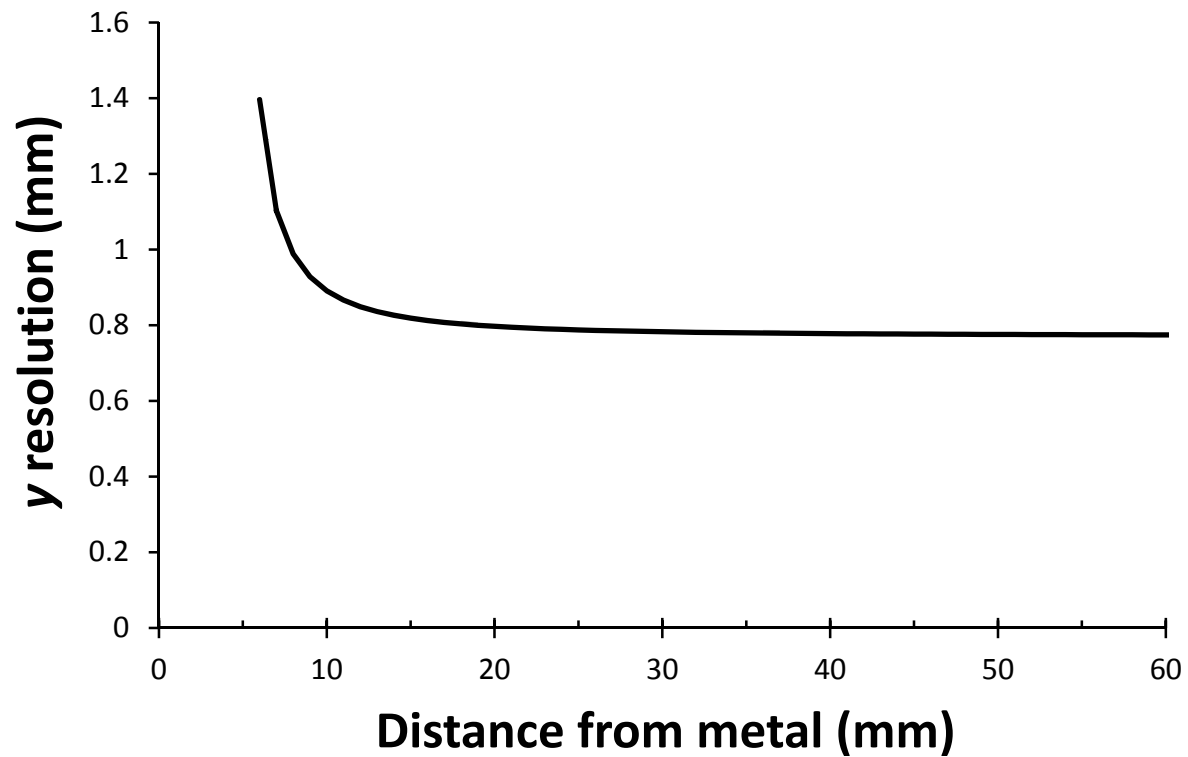


Vertical resolution



Decreased resolution near metal

Resolution near a 10 mm metal implant



MDT development timeline

