

*Spatial Resolution in CT:
How Close are we to Digital Radiography?*

Cynthia H. McCollough, PhD, DABR, FAAPM, FACR
Director, CT Clinical Innovation Center
Professor of Medical Physics and Biomedical Engineering
Mayo Clinic, Rochester, MN

DISCLOSURES

Research Support:

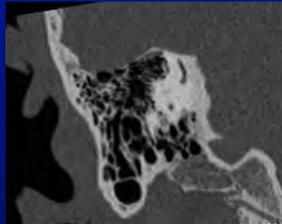
NIH	Other
EB 017095	Mayo Discovery Translation Award
EB 017185	Mayo Center for Individualized Medicine Award
EB 016966	Thrasher Foundation
DK 100227	Siemens Healthcare
HR 046158	
RR 018898	

Off Label Usage

None

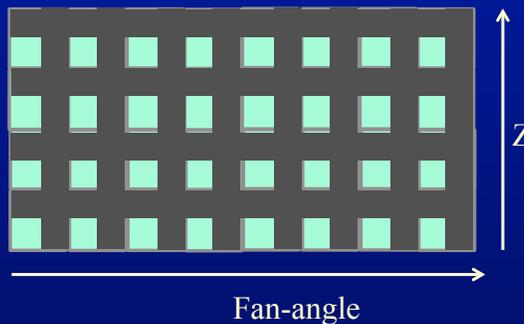
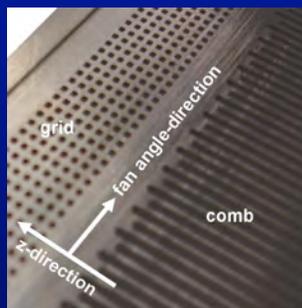
Background – Need for high resolution

- Very high spatial resolution is required to delineate the fine structures in certain clinical exams, such as temporal bone and extremity CT exams.



Lane *et al.* 2006; Purcell *et al.* 2006; Swartz and Loevner 2008; Lane and Witte 2009

Background - UHR and zUHR modes



Flohr *et al.* Med. Phys. 2007

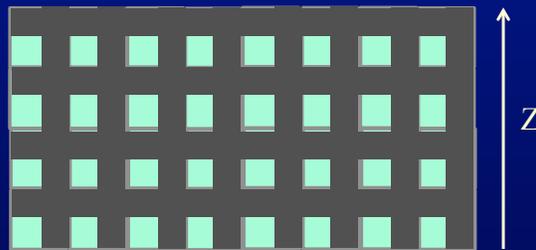
- Use of attenuating comb or grid filters to reduce the detector aperture in the fan angle (UHR) or both fan and cone angle (zUHR) to improve spatial resolution.
- **Limitation of comb filters: reduced dose efficiency**

Background – Research question

- Z axis deconvolution, combined with iterative reconstruction and an UHR scan mode, has been shown to be more dose efficient and to have better spatial resolution than a zUHR scan mode
- Just how close to digital radiography is CT resolution becoming?

Methods - Deconvolution technique

- First introduced on Definition Flash scanner with stellar detector
 - Deconvolution to reduce the blurring effect caused by the finite source and detector sizes, and detector cross talk.
 - 0.4 mm slice thickness slice from 0.6 mm collimation



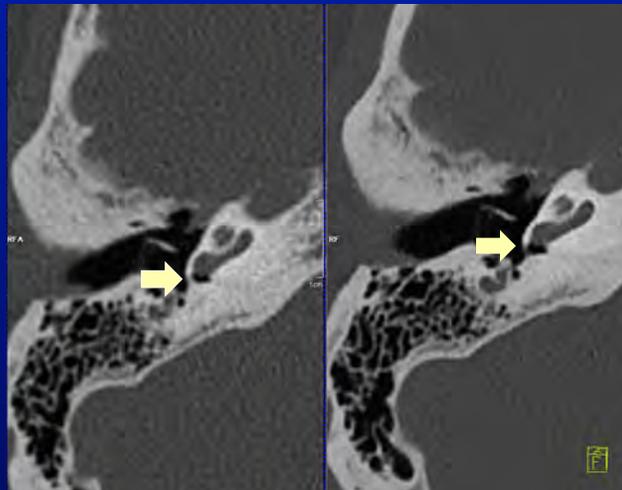
Fan-angle

McCollough et al, Med Phys, 2013

Methods

- 8 patients were identified who had prior exams with old technique and received a follow-up scan using the new technique.
- 16 sets (left and right) of temporal bones.
- 3 sets were excluded due to surgery between the 2 exams.
- 13 sets of images were included in the final evaluation.

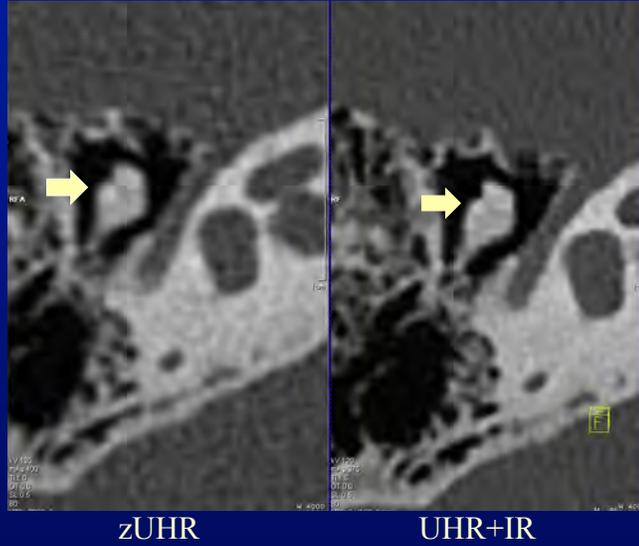
Round Window



zUHR

UHR+IR

Incudomalleolar Joint

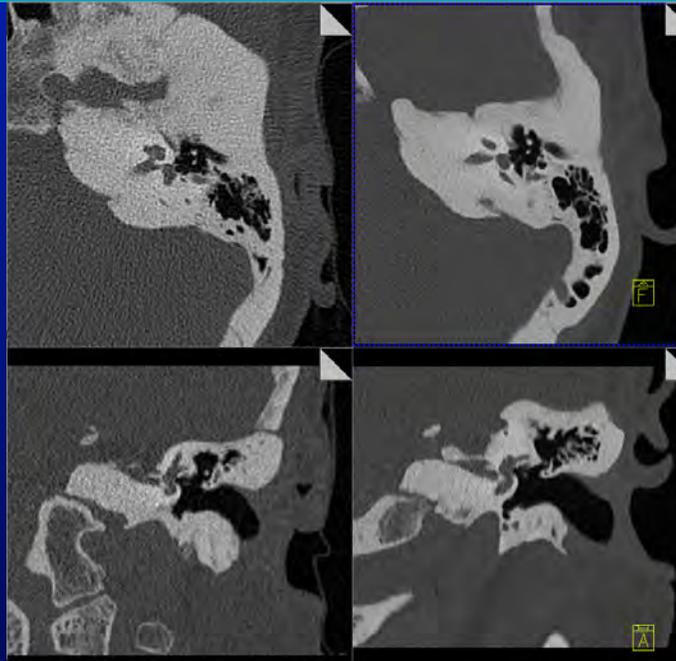


zUHR

UHR+IR

Axial

Coronal



Conclusions

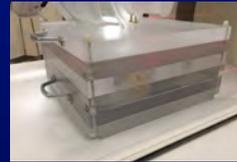
- Comparing the 2 techniques
 - Spatial resolution was comparable or improved
 - Image noise was significantly reduced by 32% with the new technique (17 to 49%)
- A potential dose reduction of 54% (31 to 74%) can be achieved.
- This technique can be applied to other CT examinations where very high spatial resolution is required (e.g., musculoskeletal CT).

Methods – Scanner

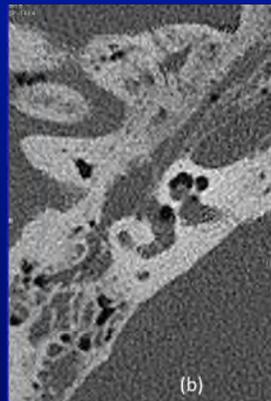
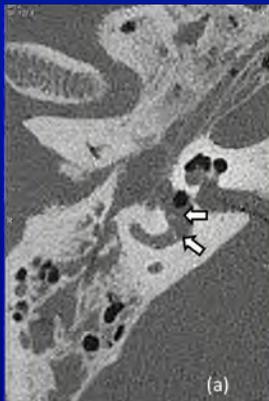
- 192 slice dual source scanner (Somatom Force)
- Potential further improvement in spatial resolution improvement
 - Smaller focal spot (0.4 mm x 0.5 mm)
 - Focal spot shaping technique (maintain focal spot size even at high mA)
 - Smaller detector cell (more detector cells are added to the in-plane detector arc)
- Potential dose reduction
 - Iterative reconstruction: Admire
 - Stellar detector with deconvolution technique

Methods – Imaged objects

- Imaging subjects
 - Human skull phantom
 - Cadaveric tissue with cochlear implants
 - Cadaver wrist
 - Patients
 - Radiographic spatial resolution target



Result – Head Phantom



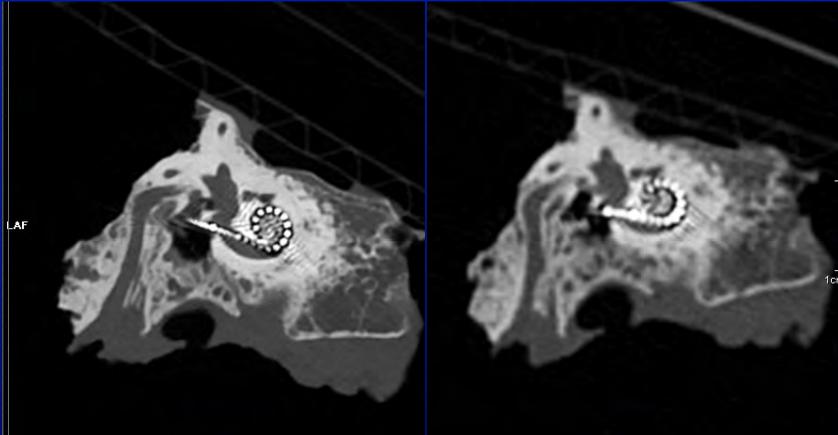
Force

Flash

Small bone fractures are better detected on the Force that are hardly visible on the Flash.

Image noise was reduced by 38%

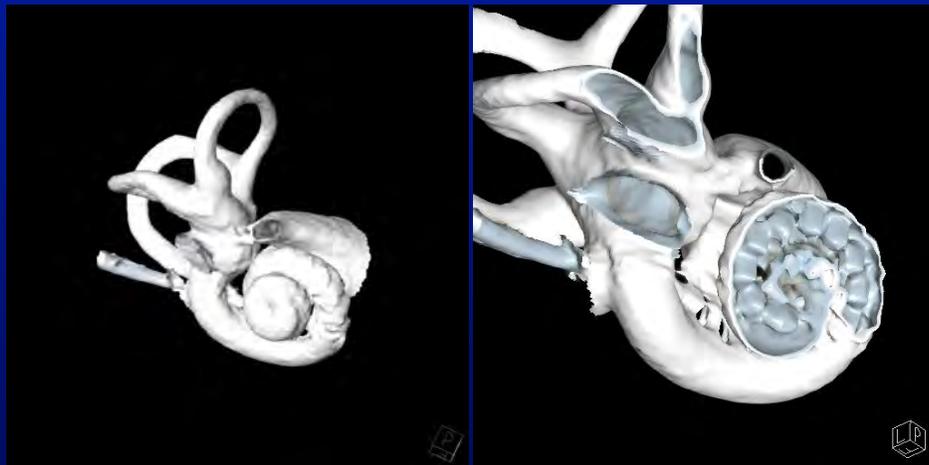
Result – Cochlear Implant



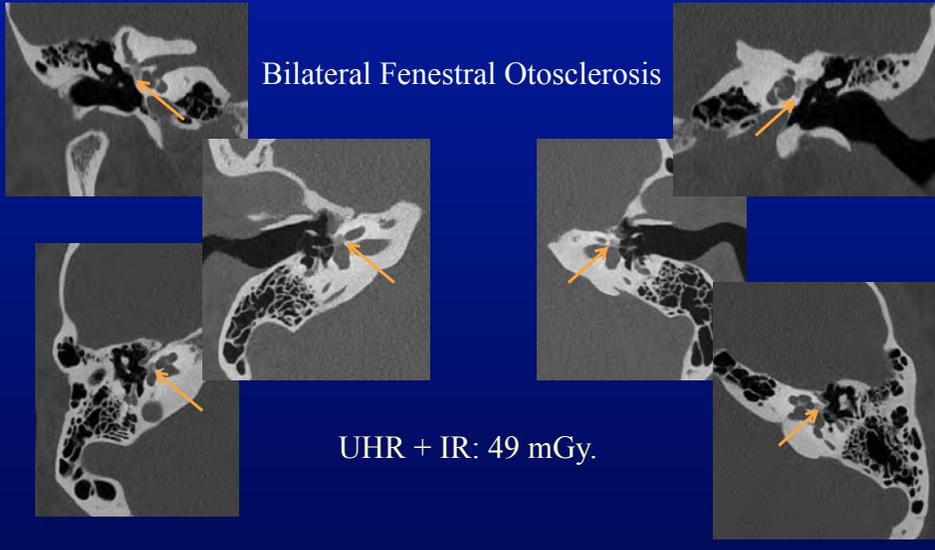
Force: 49 mGy

Flash: 82 mGy

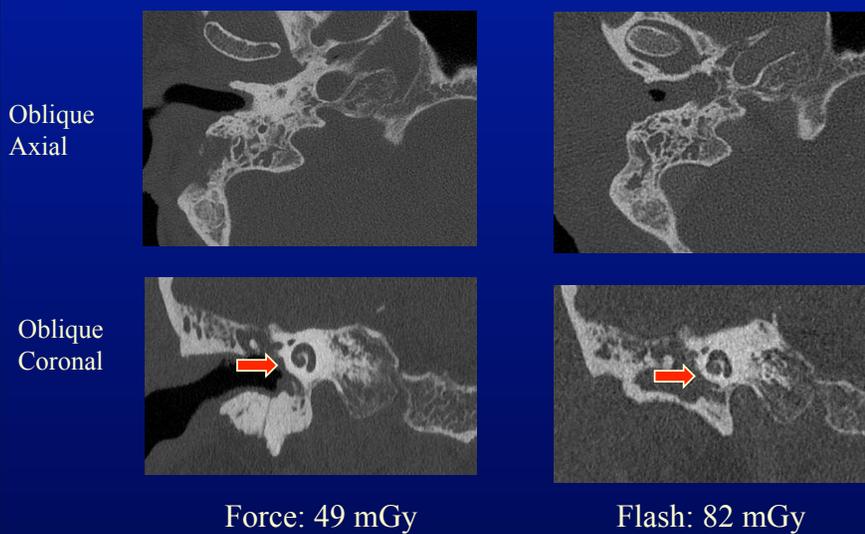
Force – Volume rendered images



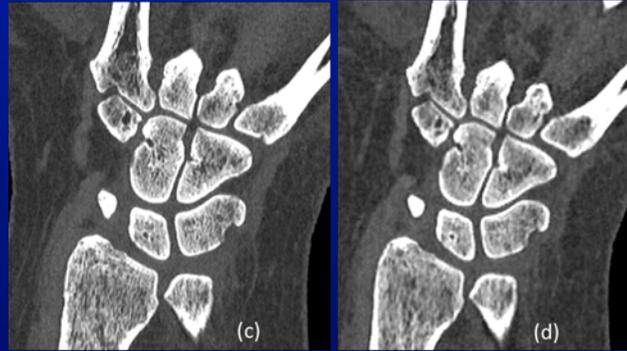
Results - Clinical case



Clinical Case: 58 year old male patient



Result – Cadaveric wrist

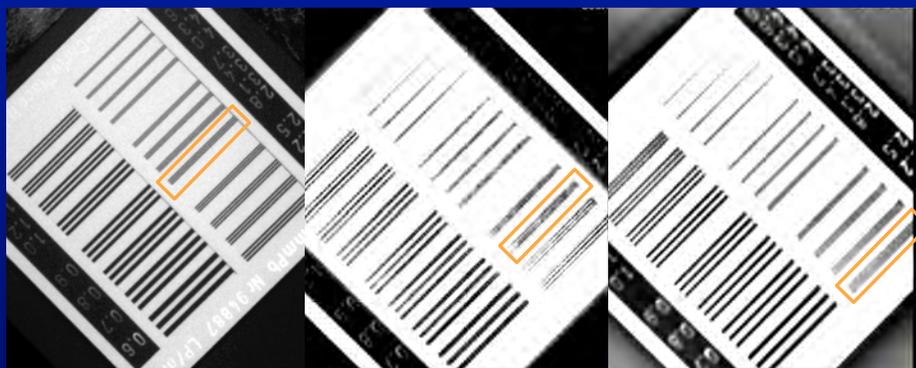


Force

Flash

Trabecular bones of the wrist were better delineated on the new scan than prior scan

Results – Resolution phantom



CR: 28 lp/cm

Force: 22 lp/cm

Flash: 18 lp/cm

Conclusions

- Spatial resolution has substantially improved on newer scanner technology.
- Deconvolution technique combined with iterative reconstruction substantially reduces image noise (up to 38%) and radiation dose.
- Image quality improvement and radiation dose reduction have been observed in phantoms, cadavers and in vivo patients.
- Spatial resolution is approaching that of digital radiography



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<http://mayoresearch.mayo.edu/ctcic>