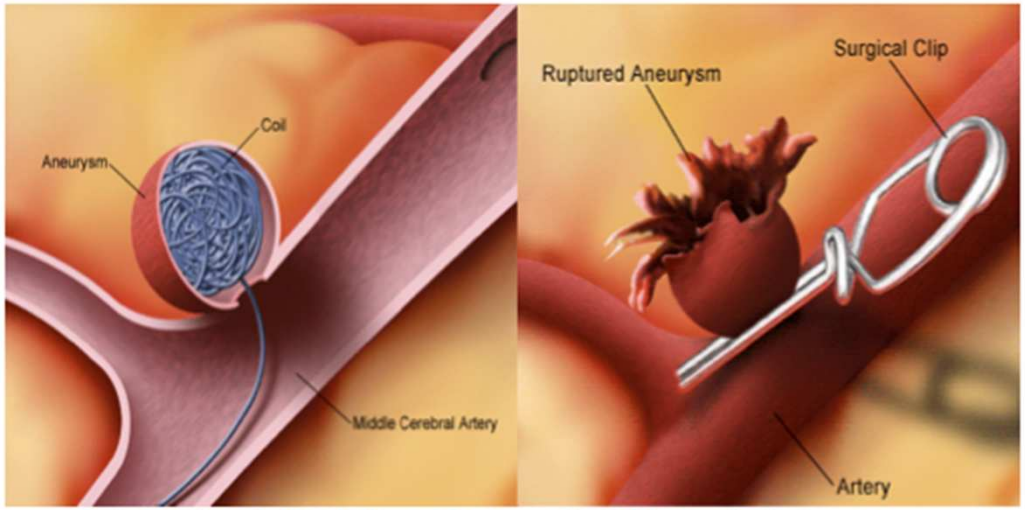
Seminar Presentation: Metal Artifact Removal in C-arm Cone-Beam CT

Marta Wells

Group 4

Project Mission

- Construction of **brain phantoms** and acquisition of CT images for a **quantitative data analysis** and assessment of (a) **image quality** and (b) **metal artifact removal** algorithm accuracy.
- Mentors: Dr. Siewerdsen, Dr. Radvany, and Dr. Ehtiati
- Group 4 Members: Carolina Cay-Martinez and Marta Wells



Coil procedure (left) and clipping treatment (right) for cerebral aneurysm.
Image provided by hopkinsmedicine.org

Paper Selection

- Frequency split metal artifact reduction (FSMAR) in computed tomography
  - Authors: Esther Meyer, Rainer Raupach, Michael Lell, Bernhard Schmidt, Marc Kachelrieß. Institute of Medical Physics, University of Erlangen-Nürnberg, Erlangen, Germany.
  - Published: The International Journal of Medical Physics Research, April 2012.

FSMAR in CT

- Purpose: To present a new MAR technique, frequency split metal artifact reduction (FSMAR), that ensures efficient reduction of metal artifacts at high image quality with enhanced preservation of details close to metal implants.
- Relevance:
  - Outlines the implementation of the FSMAR method
  - Comparison of effectiveness of various combinations of MAR algorithms

Summary of Problems

- Metal implants create severe artifacts that degrade image quality and reduce the diagnostic value of CT images.
- Many standard inpainting-based MAR methods simply replace data and lead to blurring and loss of critical information.

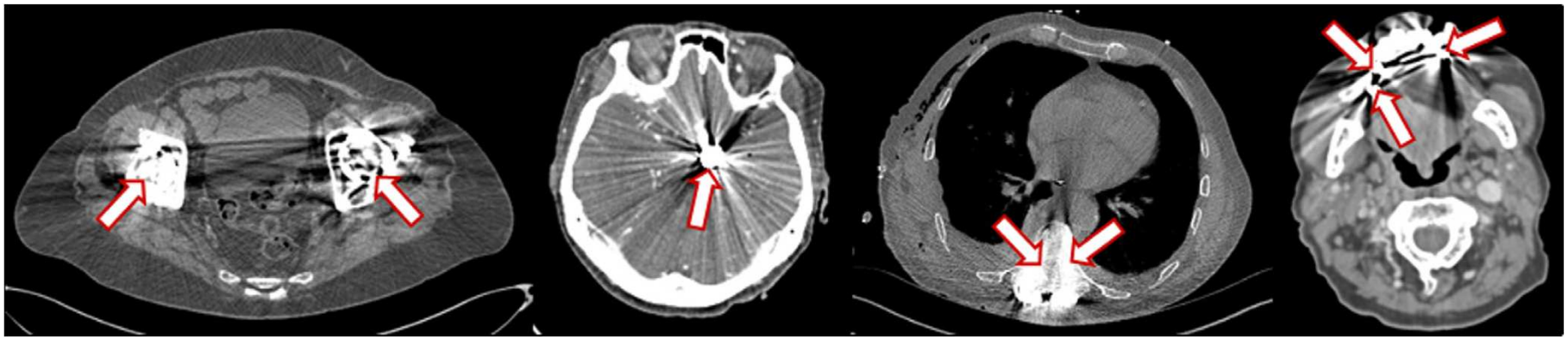


Image provided by Meyer et al.

Background

- Metal artifacts are caused by beam hardening.
- Sinogram inpainting methods of MAR use threshold segmentation to remove metal affected data.
  - New artifacts are often introduced in the sinogram restoration process.

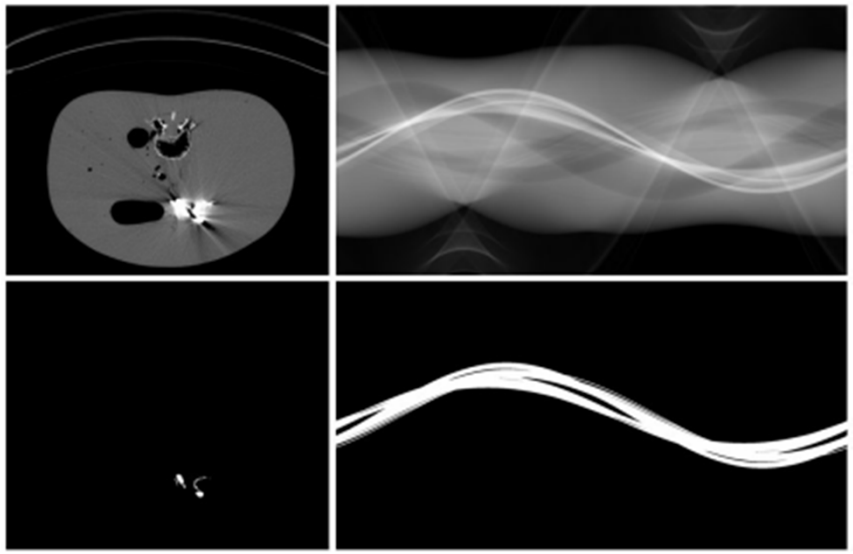
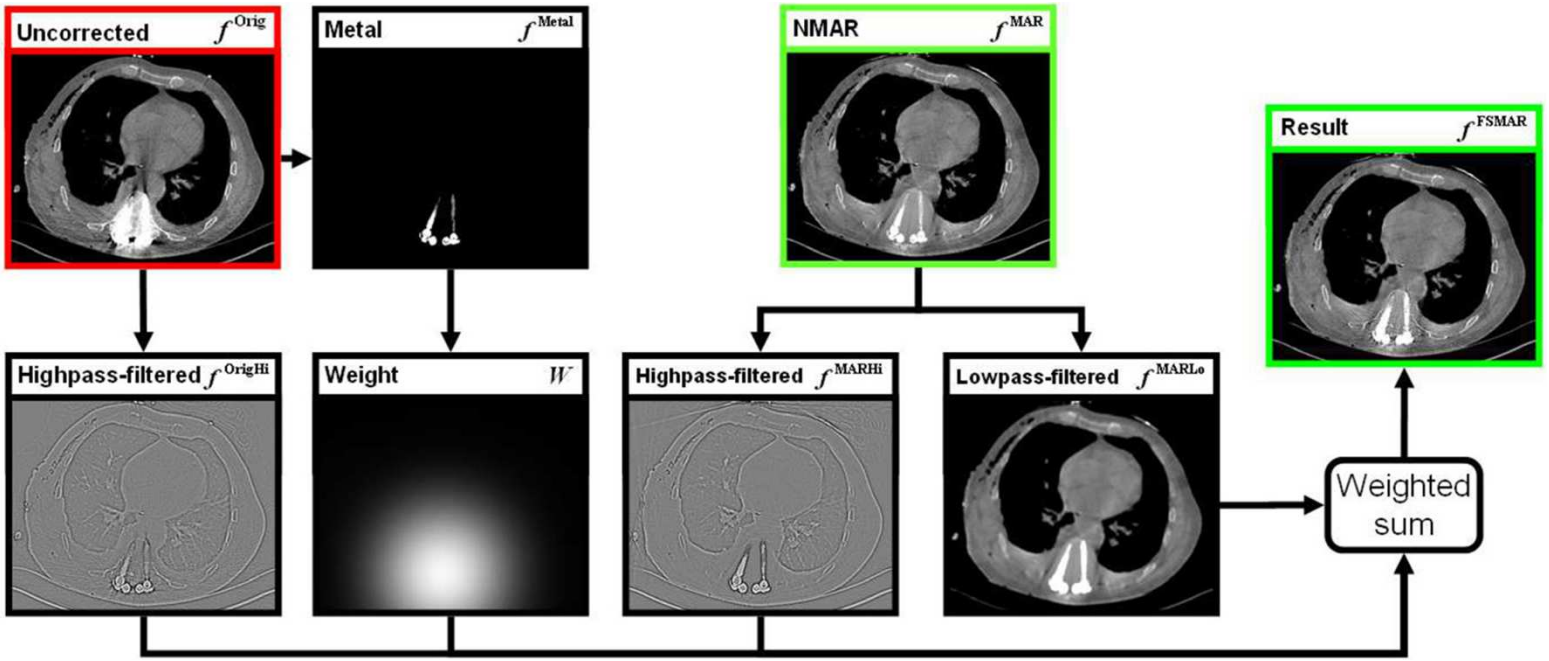


Image provided by Muller et al.

FSMAR Algorithm

1. Preprocessing
2. Segmentation of metal
3. MAR by sinogram inpainting
4. Frequency split
5. Spatial Weighting

Image provided by Meyer et al.



Results

- Hip phantom
- Spine phantom
- Two patients with hip prostheses
- Patient with internal spine fixation
- Patient with dental fillings
- Patient after coiling of an intracranial aneurysm

Results – Hip Phantom

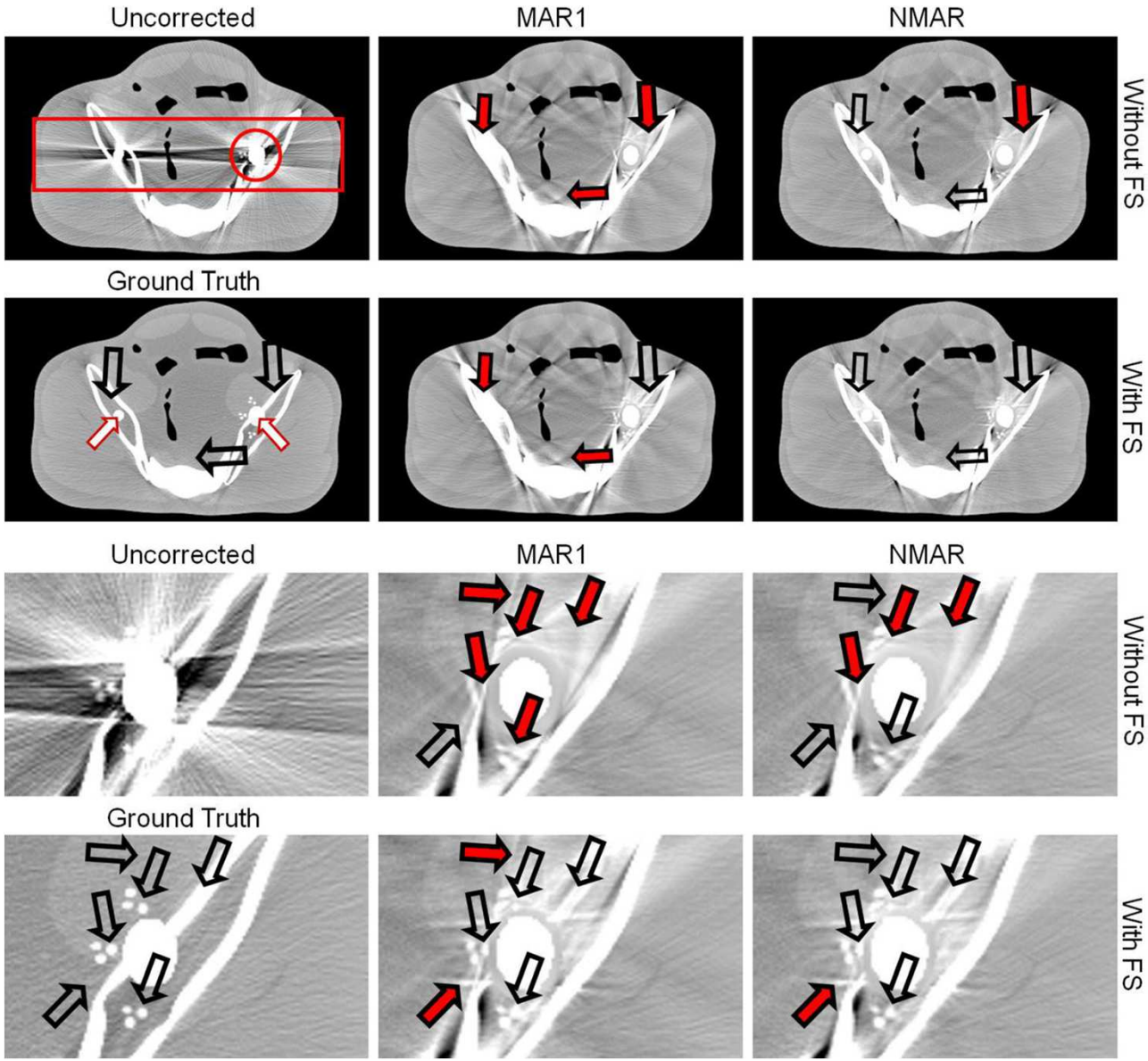


Image provided by Meyer et al.

Results – Patient Spine Fixation

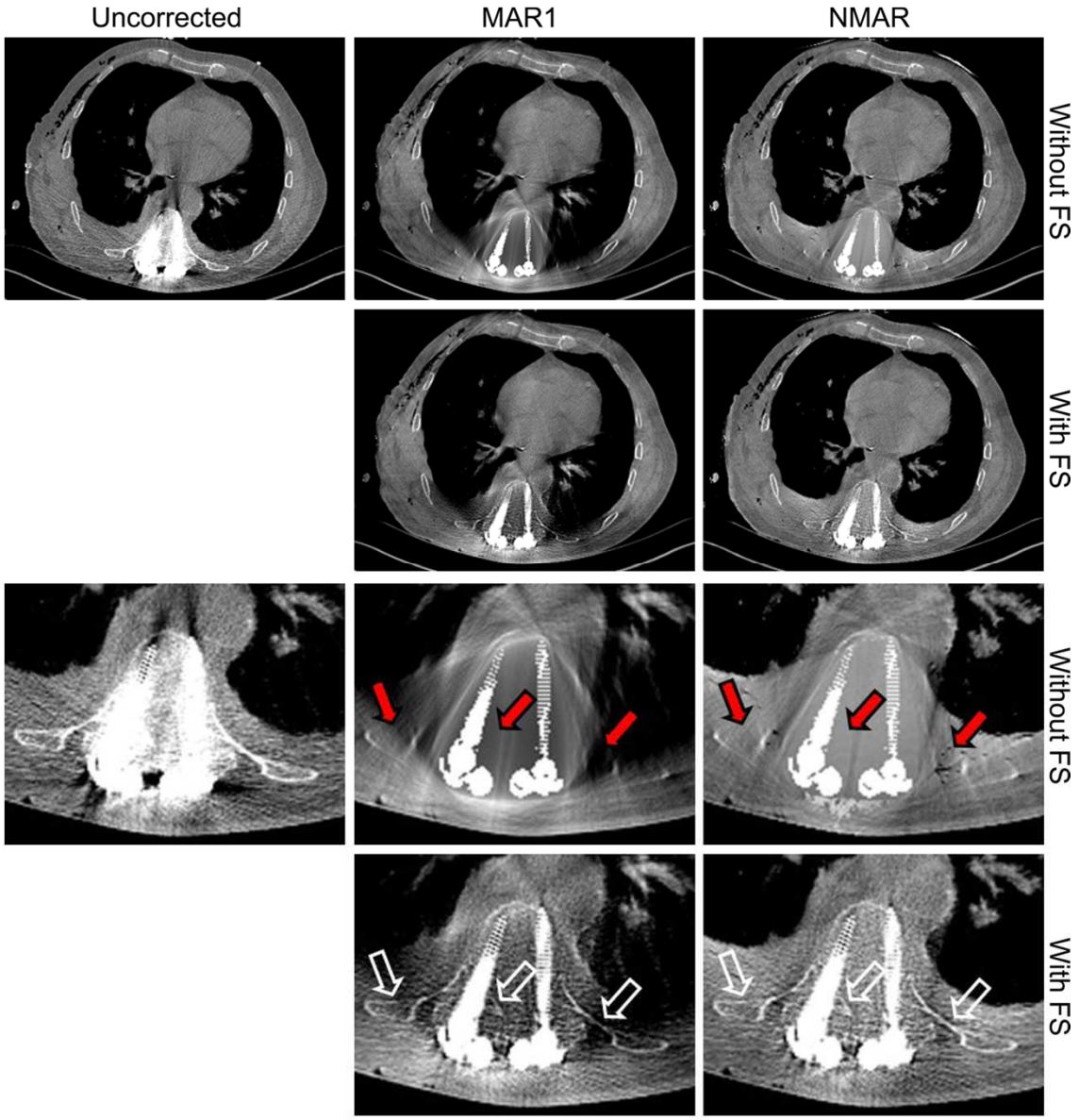


Image provided by Meyer et al.

Results - Coiling

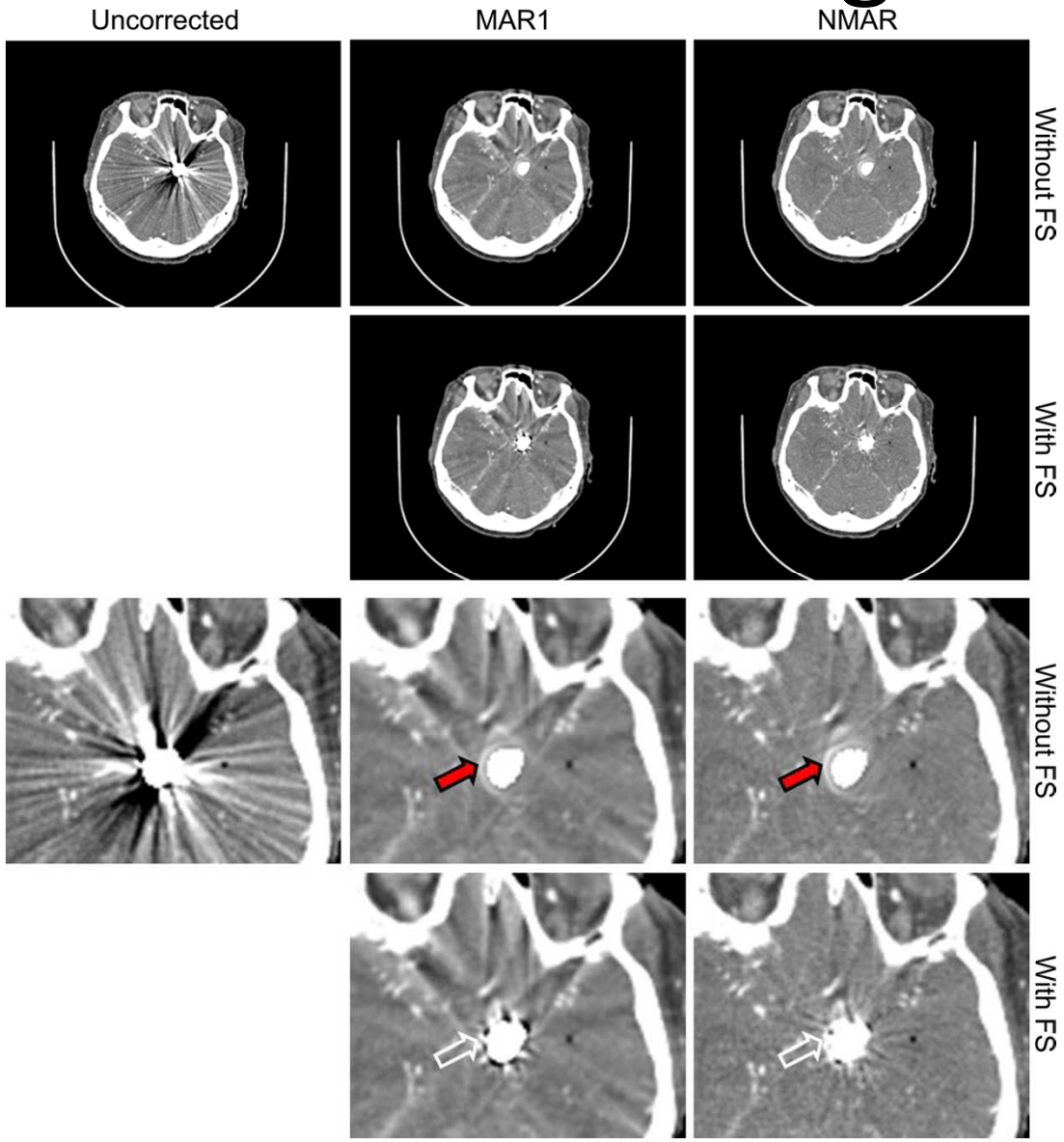


Image provided by Meyer et al.

Benefits of FSMAR

- FSMAR is easily combined with existing MAR techniques
- Advantages of FSMAR over other MAR methods alone
  - Clear edges and fine anatomical details are recovered.
  - Restoration of structures between metal implants.
  - Outline of metal implants is more accurate.
- FSMAR is computationally efficient and inexpensive.

Limitations of FSMAR

- More extensive and objective clinical evaluation by medical experts is necessary.

My Assessment

- FSMAR is more effective for larger metal implants.
- Additional clinical testing, particularly with small metal objects.
- Necessary to test FSMAR method with variable parameters
- Lacking quantitative measurements in real patient data.

Questions?

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Frequency Split Equations

$$f^{\text{OrigLo}} = f^{\text{Orig}} * G(\sigma), \quad f^{\text{MARLo}} = f^{\text{MAR}} * G(\sigma).$$

$$f^{\text{OrigHi}} = f^{\text{Orig}} - f^{\text{OrigLo}}, \quad f^{\text{MARHi}} = f^{\text{MAR}} - f^{\text{MARLo}}.$$

$$f_{ij}^{\text{FSMAR}} = f_{ij}^{\text{MARLo}} + W_{ij} f_{ij}^{\text{OrigHi}} + (1 - W_{ij}) f_{ij}^{\text{MARHi}},$$

$$\text{RMSE}(f, f^{\text{GT}}) = \sqrt{\frac{1}{I \cdot J} \sum_{i=1}^{I} \sum_{j=1}^{J} (f_{ij} - f_{ij}^{\text{GT}})^2},$$