Preliminary In Vivo and Ex Vivo Assessment of MRI Artifacts from Biodegradable Mg-10Gd Implants: Implications for Alloy Design and Imaging Protocol Optimization

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Introduction (Motivation)

* MRI is critical for preoperative evaluation of musculoskeletal diseases and early detection of postoperative complications (e.g., fracture nonunion).
* Conventional metallic implants (e.g., titanium, stainless steel) create severe MRI artifacts, compromising image quality.
* Biodegradable Mg-based implants produce fewer artifacts than titanium, enabling clearer assessment of tissue–implant interfaces.
* Some alloying elements, notably gadolinium (Gd), may increase artifact susceptibility.
* Study aim: characterize MRI artifact profiles of Mg-10Gd implants using in vivo cortical bone fracture healing models and ex vivo trabecular bone samples.

Materials and Methods

Animal model

* Female Sprague–Dawley rats (n = 6), femoral osteotomy
* Intramedullary cylindrical Mg-10Gd pins (Ø 1.2 mm × 5 mm)
* 12 weeks postoperative: micro-CT + T1-RARE MRI.

Ex vivo study

* Chicken humerus (n = 3)
* Transcortical implants: pure Mg, Mg-10Gd, PEEK implants
* Imaging with T2-RARE MRI; micro-CT as reference.

Imaging system

* 7 Tesla small animal MR system (Bruker BioSpec).
* vivaCT 80 micro-CT (Scanco Medical AG).

Results

In vivo T1-RARE MRI (Fig.1)

* Signal voids around Mg-10Gd → localized susceptibility artifacts.
* Artifacts obscured peri-implant cortical bone & adjacent tissues.
* Micro-CT showed clear visualization of cortical bone + implant.

Ex vivo T2-RARE MRI I (Fig.2, Fig.3)

* No hardware: clear visualization of cartilage + trabecular region.
* Pure Mg & PEEK: minimal artifacts / structures clearly visible.
* Mg-10Gd: more pronounced artifacts: signal distortion and loss, obscuring adjacent trabecular structures.

Discussion

Problems

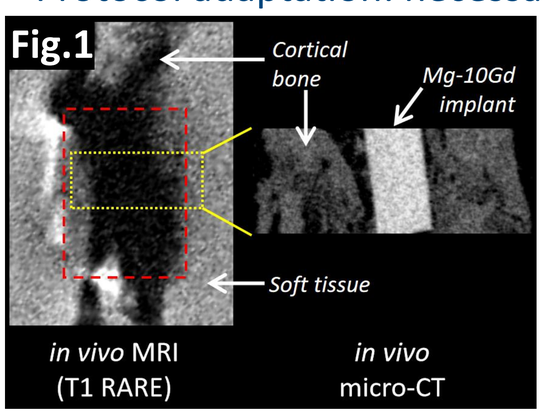
* Magnetic susceptibility mismatch between Mg-10Gd and tissue , causing field inhomogeneities, misregistration, signal voids, may hinder assessment of osseointegration & local tissue responses.
* Particularly affects FSE-based sequences (e.g., RARE).

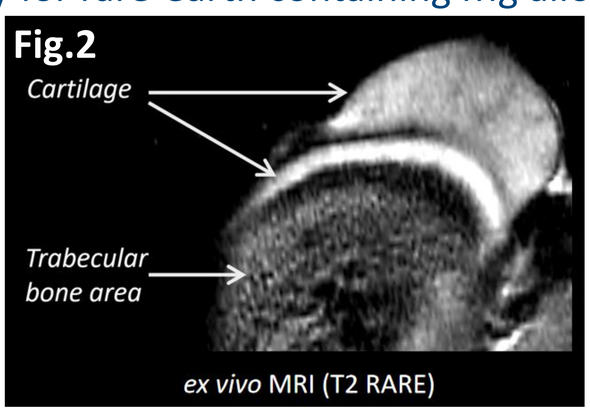
Future directions

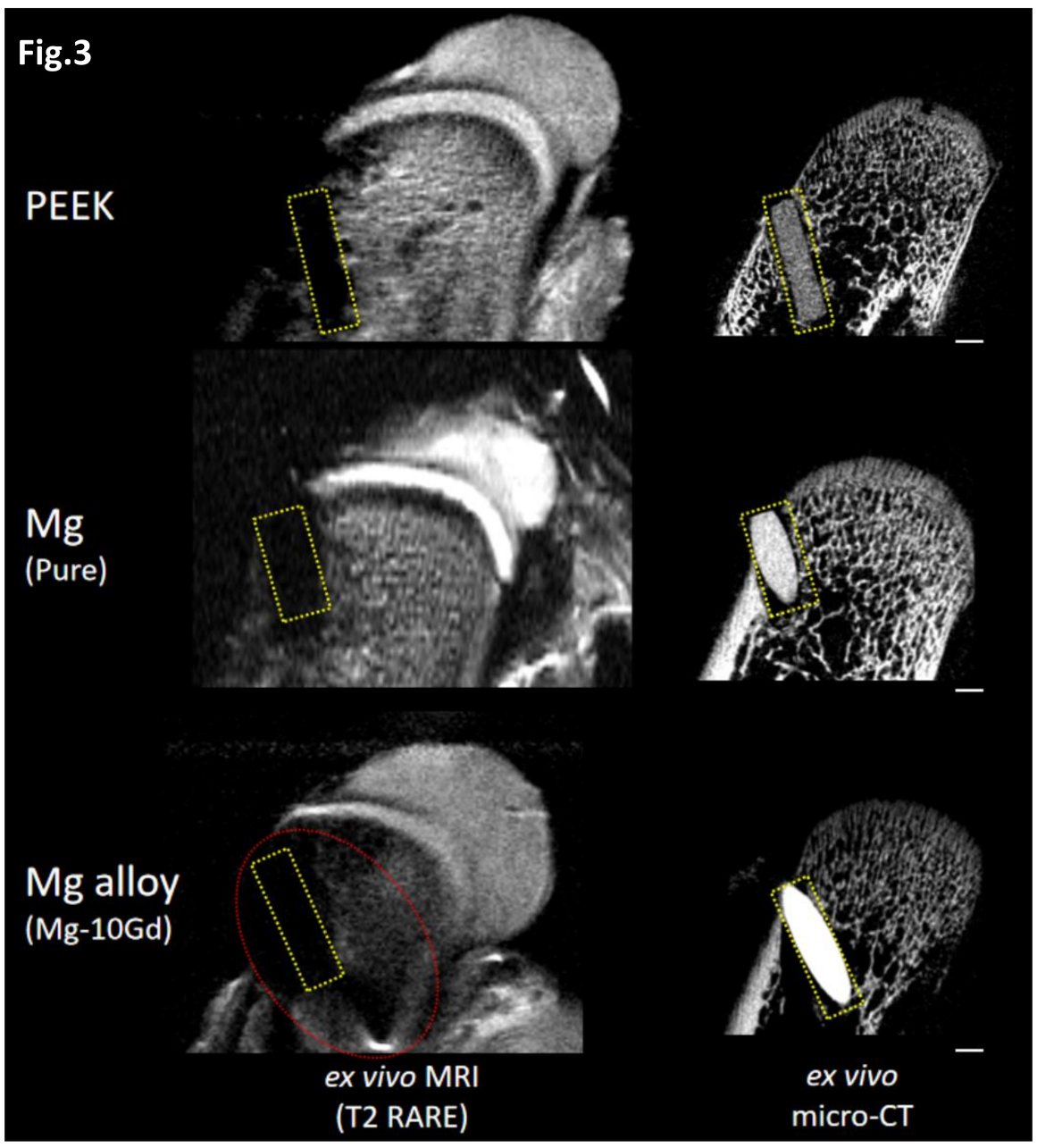
* Test broader sequence range for artifact mitigation.
* Evaluate RF-induced heating of Mg implants during MRI.

Conclusion

* Mg-10Gd implants induce regional artifacts in T1- & T2-RARE scans
* Findings underscore the need for alloy-specific artifact evaluation.
* Protocol adaptation: necessary for rare-earth containing Mg alloys.







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