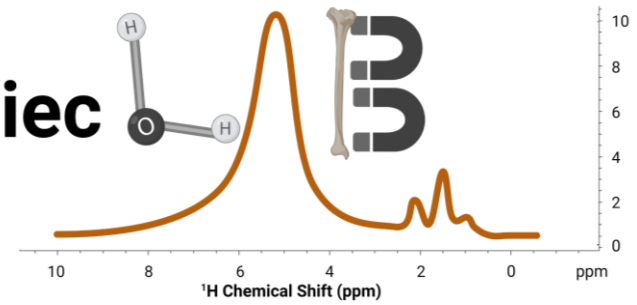
IUPUI
DEPARTMENT OF BIOMEDICAL ENGINEERING

Surowiec



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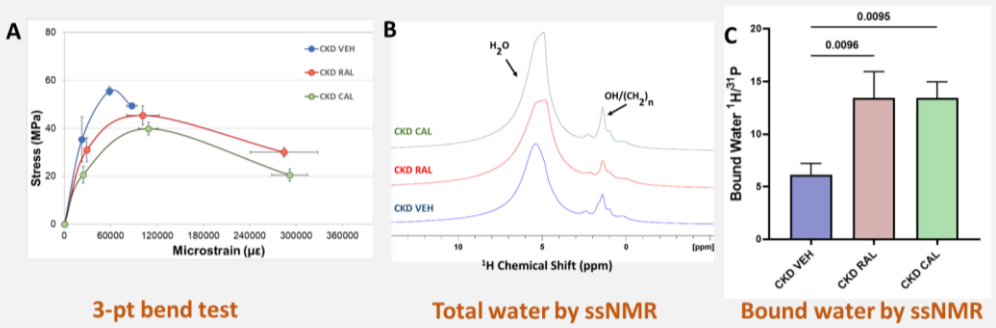
We apply cutting-edge quantitative imaging and spectral technologies to uncover tissue-level mechanisms in musculoskeletal (MSK) biology

Bone Water as a Novel Therapeutic Target

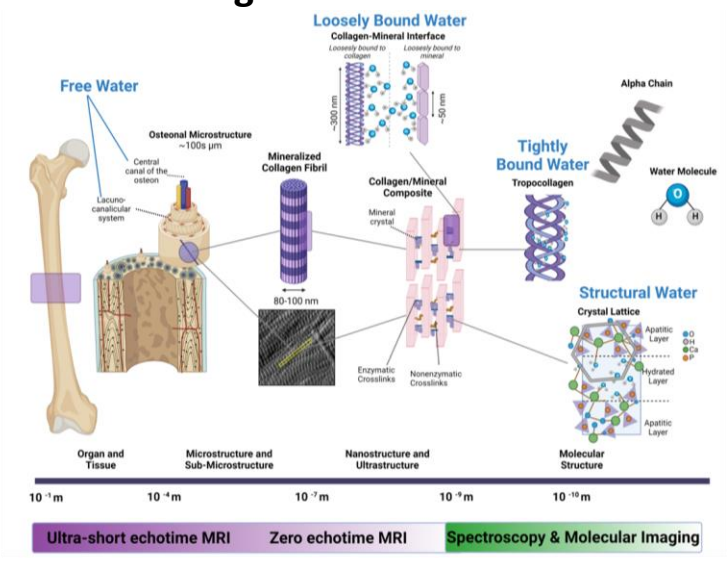


3-pt bend test | **Total water by ssNMR** | **Bound water by ssNMR**

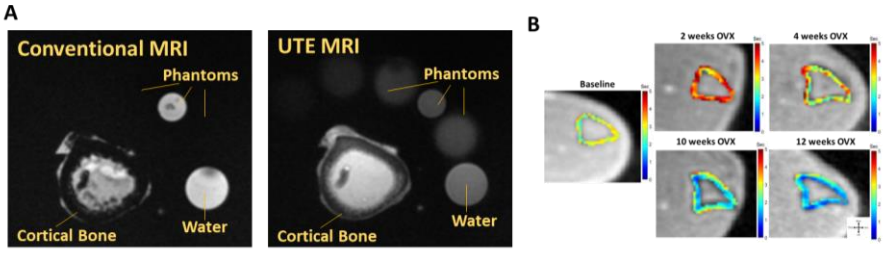
A) Chronic kidney disease (CKD) bones treated with Raloxifene or Calcitonin are tougher with enhanced post-yield properties and have (B) increased total water content with broader peaks in the cortex driven by (C) elevated bound water content.

Bone water plays an integral role in governing bone's mechanical properties. Even so, the current bone treatment dogma focuses on improving mineral mass/architecture and neglects the role of water in bone health. We are interested in **bone water as a viable therapeutic target to improve bone quality** and are working to identify interventions capable of increasing bone hydration.

Elucidating the Role of Bone Water

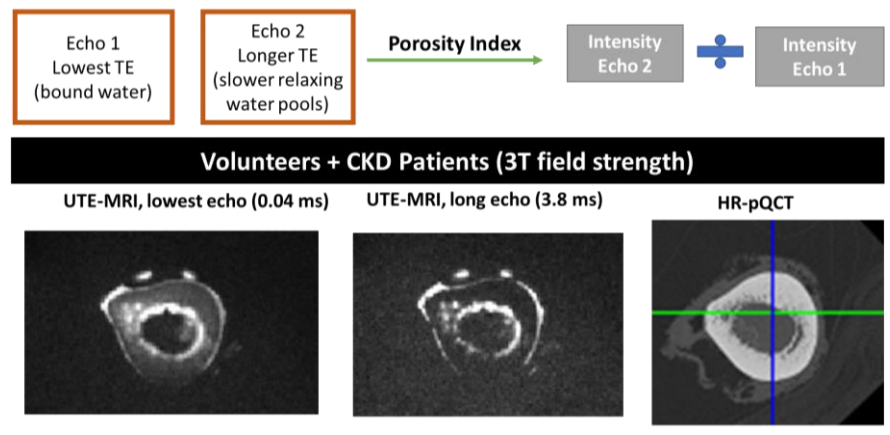


Ultra-short Echo Time (UTE) MRI of MSK Tissues: Maximizing sequence utility for biomarker development



A) Example of human bone, pure water, and D_2O-doped water phantoms scanned using conventional MRI (left) and UTE-MRI. The bone cortex and D2O phantoms gain signal using UTE and are completely void of signal information using conventional MRI. B) Example of quantitative parametric mapping using T1 mapping following matrix degeneration post- OVX in one rat.

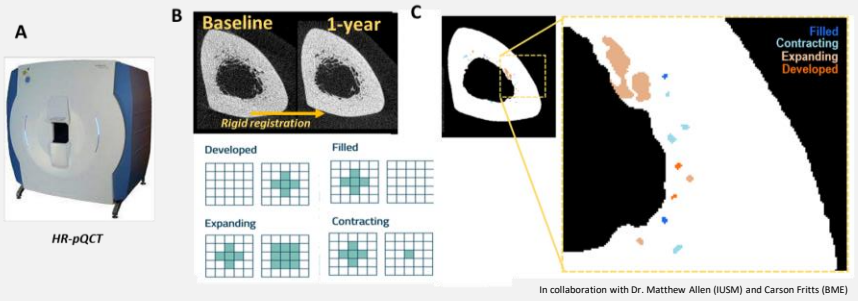
UTE-MRI has altered how we image tissue by achieving nominal echo times (time delay between excitation and signal acquisition) ~100 times shorter than conventional MRI. This has allowed, for the first time, imaging of tissues with extremely short T2 (i.e., little water) such as bone and tendon. **We are developing a comprehensive suite of bone-based MRI measures/biomarkers** that can be used (safely, no radiation) in longitudinal studies to advance our understanding of skeletal disease.



UTE-MRI porosity vs. high-resolution quantitative peripheral computed tomography (HR-pQCT) preclinical gold standard for determining cortical porosity

UTE-MRI Cortical Porosity Index is an MRI-based measure of cortical porosity which is done by exploiting the water residing in cortical pores. This is an example of how we use MRI for mineral-based measures.

Dynamic Cortical Pore Tracking using High Resolution Peripheral Quantitative Computed Tomography (HR-pQCT)

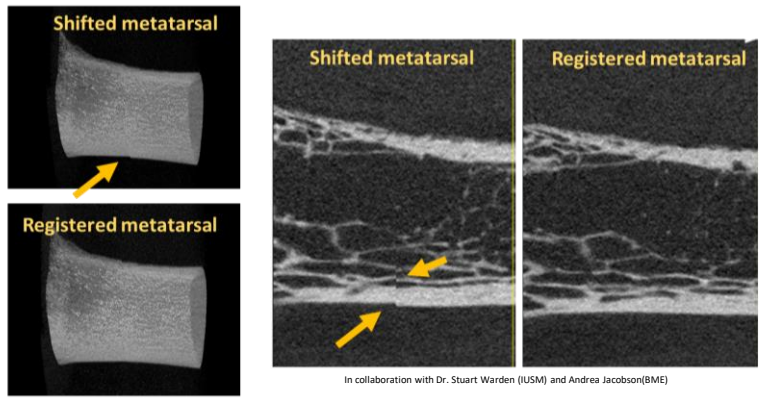


In collaboration with Dr. Matthew Allen (IUSM) and Carson Fritts (BME)

HR-pQCT (A) tibial reference (baseline) and target (1-year) images (B) taken one year apart are registered and longitudinal pore dynamics are tracked and quantified in 2D and 3D (C-D).

HR-pQCT has revolutionized the 3D clinical assessment of bone microarchitecture by achieving extremely high spatial resolution (61-82 µm isotropic voxel size) with nominal radiation cost (~0.025 mSv). **Cortical pores,** or holes within the cortex, are a common feature of bone loss and account for nearly 70% of the bone's elastic modulus (stiffness). **We are developing image analysis approaches capable of longitudinally tracking and quantifying individual pore dynamics** to uncover mechanisms responsible for porosity development and support identification of therapeutics capable of pore infilling.

3D Multi-Stack Alignment and Registration of Clinical HR-pQCT Images



In collaboration with Dr. Stuart Warden (IUSM) and Andrea Jacobson(BME)

Yellow arrows indicate the stack shift artifact suggesting changes in the average position between the stacks

Patient motion during image acquisition can cause a "stack shift" artifact resulting in loss of valuable information. We are using **image registration techniques** to improve the number of usable clinical HR-pQCT scans.