RESEARCH GROUPS


Peder Larson, PhD

Body Imaging

In this issue of *Images*, we are featuring work by Daehyun Yoon, PhD, who joined the Body Imaging Research Group in January 2023. Yoon is focusing his image acquisition and analysis expertise on diagnosing a broad range of peripheral pain conditions. His research uses PET and MRI to improve the visualization and characterization of peripheral pain generators for enabling directly targeted treatments. UCSF is unusual – perhaps unique in the US – for having MRI scanners with 0.55, 1.5, and 3.0 Tesla main magnetic field strengths from the same vendor (Siemens). This distinction presents a rare opportunity to rigorously assess the benefits and trade-offs of all three field strengths in postoperative imaging of the rapidly increasing patient population with metallic implants.

Our second story highlights bone quality research. Galateia Kazakia, PhD, and her lab are building on a well-established program in bone quality research to develop novel image analysis approaches to improve our understanding of how bone structure changes in Type 2 diabetes and the implications for clinical status of patients.

> “People are living longer, and as a result, we’re seeing more patients experiencing chronic pain conditions associated with implant/joint replacement pain. At UCSF, we have the opportunity to **develop an optimal MRI strategy to diagnose and treat pain sources for these patients.**”
>
> ~ Daehyun Yoon, PhD, Assistant Professor

Learn more at https://tiny.ucsf.edu/body

Advanced Imaging of **Peripheral Pain Generators**

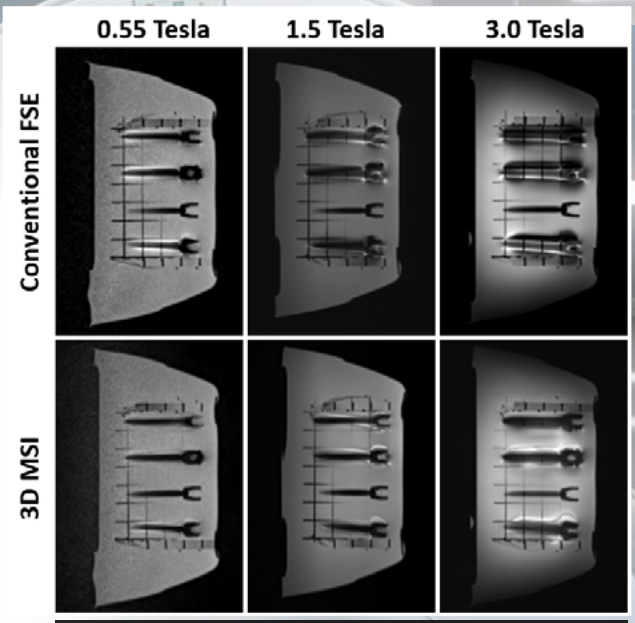
By Daehyun Yoon, PhD

Daehyun Yoon, PhD, Assistant Professor

Imaging at 0.55, 1.5, and 3.0 Tesla. The main magnetic field strength of clinical MRI scanners has shifted from 1.5 Tesla to 3 Tesla over the past decades. This is because higher field strength offers a higher signal-to-noise ratio, which, in turn, enables higher spatial-resolution imaging. Contrary to this trend, a new 0.55 Tesla whole-body MRI scanner was recently released. The primary motivation for this mid-field MRI scanner is to improve the accessibility to MRI with significantly reduced initial and maintenance costs.

Aside from the cost-effectiveness, the 0.55 Tesla scanner offers a unique advantage over the 1.5 Tesla and 3 Tesla scanners: substantially reduced magnetic field inhomogeneity. This is particularly useful for MRI of patients with metallic implants. Metal in the human body perturbs the applied magnetic field proportionally to the main field strength of the MRI scanner. The resulting main field inhomogeneity causes image distortion artifacts, which are much more severe in 3 or 1.5 Tesla MRI than in 0.55 Tesla MRI.

Approximately one million joint arthroplasties and 400,000 spinal fusions are performed in the United States annually. The number of cases is estimated to double by 2030 with the steady increase of the aging population and younger patients. Unfortunately, 10 percent to 30 percent of patients suffer from symptomatic postoperative complications. MRI can enable the early detection of periprosthetic tissue damage if the prohibitive imaging artifacts near implants can be corrected. The substantial metal artifact reduction at 0.55 Tesla MRI provides a new opportunity to develop the next-generation MRI examination of postoperative complications.



Conventional fast spin-echo (FSE) and 3D multispectral imaging (MSI) MRI images of a water phantom with three stainless steel pedicle screws and one plastic replica screw (third screw from the top) acquired at 0.55 Tesla, 1.5 Tesla, and 3 Tesla are shown on the right. At each field strength, 3D MSI images present reduced signal pile-up (abnormally bright) and signal loss (abnormally dark) artifacts compared to conventional FSE images. In both FSE and 3D MSI images, 0.55T images show the least metal-induced artifacts among different field strengths.

116 Million **Adults in the US** suffer from common chronic pain conditions, more than the number affected by heart disease, diabetes, and cancer combined.

The cost of pain management for people who suffer from these chronic conditions **$635 Billion**

30% **Treatments are only effective 30 percent** of the time, partly due to our inability to pinpoint pain generators.

Imaging **Cortical Bone Vasculature**

By Galateia Kazakia, PhD

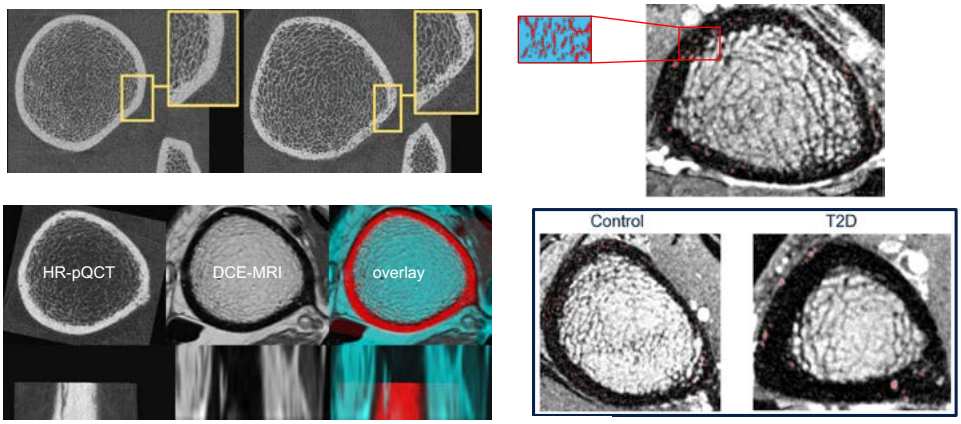
A decade ago, Thomas Link, MD, PhD, was senior author on a paper in *J Bone Miner Res*[1] that suggested that severe deficits in cortical bone quality are responsible for fragility fractures in postmenopausal diabetic women. Building on that work, our Bone Quality Research Lab has developed a technique to visualize intra-cortical vessels and assess the structural changes that can degrade bone strength.

To understand how the normal vascular structure is altered, rendering the compact cortical shell very porous in some patients, our lab developed a technique that uses both dynamic contrast-enhanced MRI and high-resolution peripheral quantitative computed tomography (HR-pQCT)[2]. Using this new capability, we have analyzed baseline data of the distribution and size of intracortical vessels in patients with diabetes compared to healthy controls.

One imaging challenge is deducing which cortical bone pores house blood vessels and which canals are filled with fat. Using this technique, contrast is injected into the patient and multiple MRI scans are taken to track how the contrast moves through the veins, allowing researchers to image their structure. The cortical bone microstructure itself does not show up well on MRI, but HR-pQCT can visualize the very fine details of the internal bone structure, allowing researchers to see the pores and canals in the bones through which the blood vessels could travel, while the MRI identifies which actually have vessels threaded through them. Earlier work by the Bone Quality Research Lab has documented that pores that do not contain vessels are filled with fat[3].

Results indicate that patients with diabetes have fewer and larger vessels through their bone, whereas in the controls the vessels are more homogeneously distributed and small. We expect that determining the content and spatial distribution of cortical pore space will reveal the biological systems influencing pore expansion.

The overall goal of this study is to understand the longitudinal evolution of human diabetic bone disease and to investigate and visualize the underlying biological processes that drive increased cortical porosity in the setting of T2D. Filling this knowledge gap will elucidate appropriate cellular targets for drug development to prevent or reverse pathological pore development and the associated skeletal fragility.



Dual modality bone vasculature imaging

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2) Löffler MT, Wu PH, Kazakia GJ. MR-based techniques for intracortical vessel visualization and characterization: understanding the impact of microvascular disease on skeletal health. Curr Opin Endocrinol Diabetes Obes. 2023 Aug 1; 30(4):192-199. doi: 10.1097/MED.0000000000000819. Epub 2023 Jun 19

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