# Relaxation Time Discriminated $^1$H NMR for Bone Mechanical/Fracture Property Diagnosis

VANDERBILT UNIVERSITY
CTTC Center for Technology Transfer & Commercialization


## Summary

Advances in modern MRI pulse sequences, including ultrashort-echo time and related MRI methods for imaging short T2 signals, have enabled clinically-practical cortical bone imaging. Researchers at the Vanderbilt University Institute of Imaging Science have developed a method of distinguishing and quantifying nuclear magnetic resonance (NMR) signals for cortical bone analysis.


## Addressed Need

Human cortical bone is known to contain a distribution of T1 and T2 components attributed to bound and pore water, although existing clinical imaging approaches do not discriminate bound from pore water on the basis of their relaxation properties. This leaves X-ray based methods as the only option for cortical bone analysis; however, X-ray imaging does not provide the quantitative results necessary for an accurate analysis of a patient's bone structure and mechanical properties in conditions such as osteoporosis and osteopenia. The present technology utilizes existing MR scanners to predict the fracture properties of bone, providing clinicians with the ability to quantitatively assess patients for future fracture risks and treatment responsiveness.

## Technology Description

This technology utilizes clinically-practical MRI methods for distinguishing bound and pore water signals from cortical bone based on T2-selective adiabatic pulses as well as T1 characteristics and correlates these signals to mechanical properties of cortical bone. The methods are validated in a population of ex vivo human cortical bones and with clinical evaluations of osteoporosis and osteopenia patients. Results show that the two MRI methods provide good estimates of bound and pore water that correlate to bone mechanical properties with exceedingly high sensitivity and specificity. As such, these protocols provide diagnostically useful tools for assessing bone fracture risk. Recent developments in the use of two-dimensional ultra-short echo time (UTE) in NMR have led to advances in reducing MR scan times of cortical bone from thirty minutes to thirty seconds without a significant loss of quality.

## Competitive Advantages

- Quantitative measurement of bone composition for fracture risk or disease/therapy assessment
- No ionizing radiation
- Easily implemented on existing MR scanners with 2 or 3-dimensional imaging protocols
- Short scan time, allowing for robust imaging of multiple bone sites per sitting and the extension of the technique to lumbar vertebrae imaging

## Intellectual Property Status

- Issued US Patent: US8923948
- Publications: PLoS One. 2011; Magnetic Resonance in Medicine 2012; Radiology 2015; Magnetic Resonance in Medicine 2017;

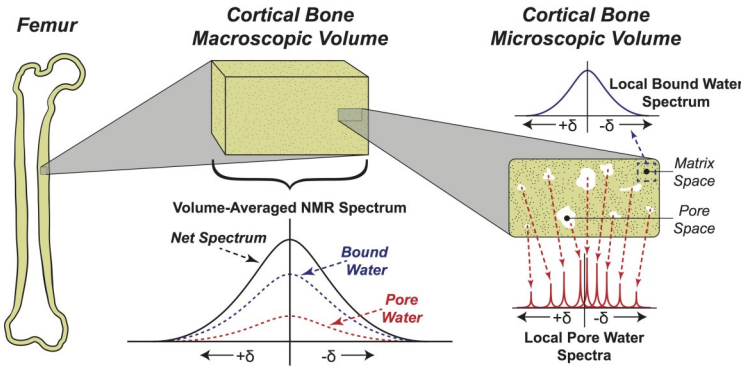


Figure 1: An overview of the present method for assessing the mechanical properties of cortical bone using MRI is shown.


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