# Emerging Technologies for Clinical NueroImaging: Ultra-High Field MR: Multi-Nuclear Imaging

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**Highlights:**

- Quantitative non-proton MR imaging is practical and safe at ultra-high field and can provide unique, clinically relevant information.
- Bioscales computed from quantitative non-proton MR imaging enable access to core tissue properties and provide new insight into brain health and treatment response.

**Target audience:** Researchers wanting an overview of ultra-high field non-proton (focus on $^{23}$Na, $^{17}$O) neuroimaging and its potential clinical applications.

**Objectives:** Discuss the basic methodology of creating bioscales derived from quantitative non-proton MR imaging and some emerging clinical applications of bioscales.

**PURPOSE:** Conventional neuroimaging based on the proton signal arising from hydrogen nuclei in water molecules provides exquisite anatomy and can inform on physiology and function. However, the complex interactions of brain metabolism involve molecules containing MR sensitive elements such as carbon, phosphorus, oxygen, nitrogen, sodium and potassium. MR imaging of these signals can provide a new perspective of brain health that may inform on early disease and treatment response.

**METHODS:** The goal of non-proton imaging is very different from conventional proton MRI. A gray scale non-proton image will never rival the SNR or resolution of a proton acquisition. The final non-proton MR image must be quantified as a bioscale that provides biochemical information about healthy and dysfunctional tissue. The reduced sensitivity of non-proton MR signals is addressed using an ultra-high field human MR scanner, optimized hardware, and acquisition schemes matched to the signal characteristics of non-proton nuclei.

**RESULTS/DISCUSSION:** Bioscales based non-proton imaging of 23-sodium [1], 17-oxygen [2], and 31-phosphorus [3] have been achieved in the human brain. These bioscales can be readily and non-invasively measured in humans and measure tissue cell fraction (TCF; sodium), the cerebral metabolic rate of oxygen consumption ($CMRO_2$, oxygen), and the ATP/PCr ratio (phosphorus).

**CONCLUSION:** Bioscales derived from ultra-high field non-proton MR imaging provide non-invasive access to clinically important parameters of tissue health. Such measurements may provide the means for real-time monitoring of early disease and response to treatment, a necessary step to create early interventions. Ultra-high field MR will continue to be a central technology in this pursuit.

**REFERENCES**:

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