# An Inductive Method to Measure Mechanical Excitation Spectra for MRI Elastography

D.B. PLEWES,[1] C. LUGINBUHL,[1] C. MACGOWAN,[2] I. SACK[3]

[1] *Imaging Research, Sunnybrook and Women's College Health Sciences Centre, University of Toronto, Toronto, Ontario, Canada*
[2] *Department of Medical Imaging, Hospital for Sick Children, University of Toronto, Toronto, Ontario, Canada*
[3] *Department of Medical Informatics, University Hospital Benjamin Franklin, Free University Berlin, Berlin, Germany*

**ABSTRACT:** Harmonic MR elastography (MRE) monitors the propagation of acoustic waves in tissues in the audio regime. Oscillatory motions with large amplitudes can induce nonlinear wave propagation effects resulting in harmonics that evolve over space. In order to understand these effects, knowledge of the motions of applied mechanical motion is needed to rule out the presence of harmonic motion arising from the mechanical source. We propose a simple technique to measure the spectral content of mechanical excitation based on the use of a set of detection coils mounted on the elastography excitation system. The motion of these coils causes a small signal to be induced from the applied static magnetic field of the MRI system. A detailed analysis shows that quantitative assessment of excitations is possible with correct geometrical arrangement of the detector coils. However, it shows that nonlinear effects can also occur depending on the alignment of the detection coils with respect to Bo. The system is easy to operate and allows for the time resolved observation of the actuator motion for each experimental setup. The system is intended to be used before and after MRE experiments to determine excitation spectral content and repeatability. We demonstrate its use in a one-dimensional elastography experiment and show that this information is an essential prerequisite for studying material nonlinear elastic properties using MRE.
Concepts Magn Reson Part B (Magn Reson Engineering) 21B: 32–39, 2004

**KEY WORDS:** elastography; nonlinear acoustics; wave propagation; elastography instrumentation

## INTRODUCTION

Harmonic MR elastography (MRE) requires the application of harmonic motion, which in turn interacts with the soft tissues under examination. Typically, the delivery of this motion is achieved with Helmholtz coils that are oriented perpendicular to the applied Bo field and then energized with alternating current (*1*, *2*). The Lorentz force arising from coil interaction with the applied field generates a torque on the coil that results in a time-dependent rotation that is coupled by various mechanical means to deliver either shear or longitudinal mechanical excitation to the patient's surface. The most elementary mechanisms uses a simple beam mounted on a bearing that directly couples coil motion parallel to the Bo field to the patient similar to that of Fig. 1. Such an arrangement results in a tiny angular oscillation of the beam with subsequent motions ranging from 1 to 1000 μm.

Imaging of the resulting tissue motions is achieved with a phase sensitive method that applies an oscillating gradient, which is phase-locked to the applied mechanical excitation (*3*). This generates a phase image of wave motion throughout the object that can be followed in its temporal evolution by adjusting the phase relation between the applied gradients and mechanical excitation. This experiment has been repeated by several investigators ranging in frequency

---

Received 24 September 2003; accepted 28 September 2003

Correspondence to: D.B. Plewes; E-mail: don.plewes@sw.ca

Concepts in Magnetic Resonance Part B (Magnetic Resonance Engineering), Vol. 21B(1) 32–39 (2004)