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DEVELOPMENT OF PRECLINICAL MRI ELASTOGRAPHY AT 7T: AN ORIGINAL APPROACH FOR THE NON-INVASIVE MECHANICAL CHARACTERIZATION OF MOUSE ORGANS

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Magnetic Resonance Elastography (MRE) is a non-invasive imaging method that aims at mapping the mechanical properties of a tissue *in vivo* [1]. MRE is based on 3 steps: (1) **the mechanical excitation** of the organ by external generation of shear waves; (2) **the encoding of the sample response by MRI** using specific sequences; (3) **the reconstruction of the mechanical properties**. In a more marginal way, MRE has been developed for preclinical studies, such as investigation of liver [2,3], brain [4,5] or skeletal muscle [6] pathologies in mice. However, few MRE setups are currently available for preclinical purpose. In the framework of a French multicenter consortium, we have recently developed an innovative and original MRE process to investigate the mechanical properties in different organs of mouse. Available at the IRIS platform of the ICube laboratory in Strasbourg, this research tool combines performances for *in vivo* mapping of mechanical properties around three key developments:

(1) A unique 3D-printed device for generating mechanical waves within the organs has been developed and calibrated (Fig. 1A). This compact and adjustable setup uses MRI-compatible piezoelectric actuation and is adapted to spatial constraint due to the diameter of 86 mm of the resonator used (7T preclinical MRI scanner, *Bruker Biospec 70/30 USR, Ettlingen, Germany*). Articulated elements allow to precisely adjust the position of the contact between the actuator and the organ to be imaged (muscle, liver, brain...) while allowing the use of gas anesthesia and access to several different organs within the animal. Harmonic shear waves are generated at frequencies ranging from 200 to 400 Hz.

(2) Shear waves are imaged in the 7T MRI scanner (Fig. 1B) using Motion Encoding Gradient (MSG) and a dedicated single shot spin echo EPI (echo planar imaging) sequence. Up to resolutions of the order of 500 μm and fields of view of the order of a few centimeters, the acquisition times do not exceed a few seconds, leaving the possibility for non-invasive *in vivo* biomechanical studies of kinetic evolutions.

(3) The reconstruction of mechanical properties is then performed using an in-house Local Frequency Estimation (LFE) algorithm [7], similar to the method currently used on clinical MRE devices. Through the estimation of the wavelength, this algorithm allows to map the stiffness of the tissue (shear modulus, Fig. 1C).

As a first validation step, acquisitions have been performed on heterogeneous gelatin and agarose gel phantoms, mapping accurately the expected mechanical properties of these tissue-mimicking hydrogels. Then, successful acquisitions and mapping have been performed in mouse liver and muscle. Thanks to these developments and to this unique, compact device, we now have a powerful biomechanical measurement tool for the preclinical study of a large number of pathologies such as very few research centers in the world have available.

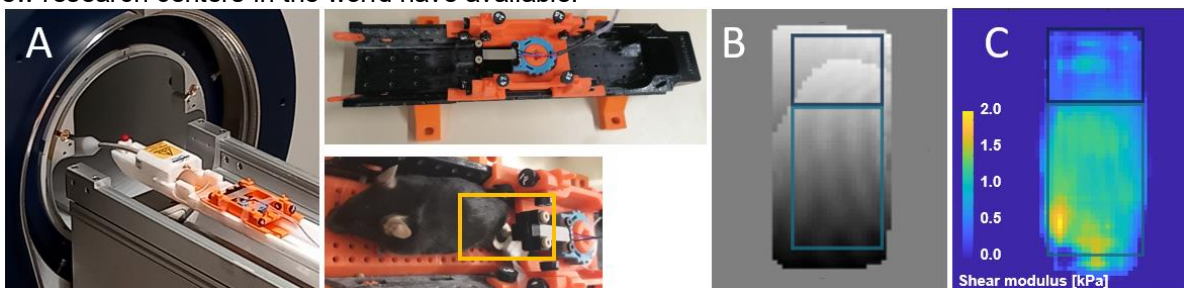


Figure 1. (A) Original 3D-printed setup overview and application to mouse hindlimb (post-mortem acquisition). Shear waves are encoded using MRI (e.g. at 400 Hz on an heterogenous agarose gel (B)) and the mechanical properties are mapped (C).

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