



Development of preclinical mri elastography at 7T: an original approach for the non-invasive mechanical characterization of mouse organs

Aude Loumeaud, Chrystelle Po, Gwenaël Pagé, Philippe Garteiser, Jonathan Vappou, Benoît Wach, Daniel George, Sabine Bensamoun, Simon Chatelin

► To cite this version:

Aude Loumeaud, Chrystelle Po, Gwenaël Pagé, Philippe Garteiser, Jonathan Vappou, et al.. Development of preclinical mri elastography at 7T: an original approach for the non-invasive mechanical characterization of mouse organs. Journées scientifiques de la Fédération de Médecine Translationnelle de Strasbourg (FMTS), Fédération de Médecine Translationnelle de Strasbourg; Faculté de Médecine, Maïeutique et Sciences de la Santé; Hôpitaux Universitaires de Strasbourg, Jun 2023, Strasbourg, France. hal-04140822

HAL Id: hal-04140822

<https://hal.science/hal-04140822>

Submitted on 26 Jun 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

Aude Loumeaud¹, Chrystelle Po¹, Gwenaél Pagé², Philippe Garteiser², Jonathan Vappou¹, Benoît Wach¹, Daniel George¹, Sabine Bensamoun³, Simon Chatelin¹

¹ICube, UMR 7357 CNRS, University of Strasbourg, France

²Inflammation Research Center, Inserm UMR 1149, CNRS ERL 8252, University of Paris, France

³BMBI, CNRS UMR 7338, University of Technology of Compiègne, France

Keywords: Elastography, MRI, *In vivo* elasticity, Preclinical imaging

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.

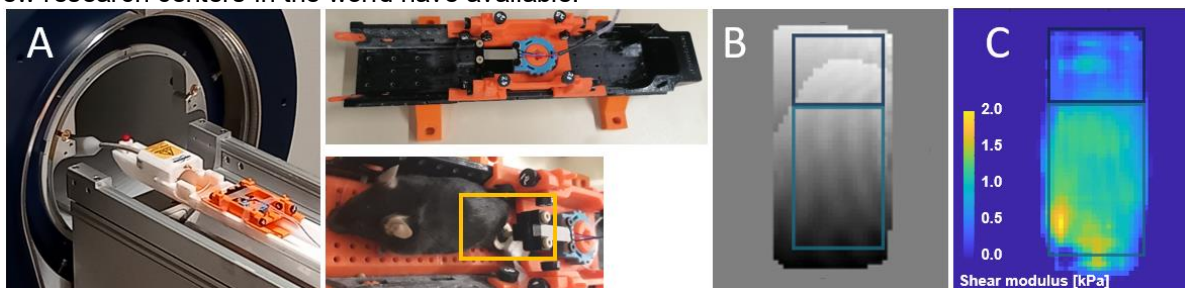


Figure 1. (A) Original 3D-printed setup overview and application to mouse hindlimb (post-mortem acquisition). Shear waves are encoded using MRI (e.g. at 400 Hz on an heterogenous agarose gel (B)) and the mechanical properties are mapped (C).

Acknowledgements: This work was supported by the ITI HealthTech (IdEx Unistra ANR-10-IDEX-0002 and SFRI STRAT'US project ANR-20-SFRI-0012), France Life Imaging (FLI, ANR-11-INBS-0006, MRESAT project) and the Research Department of UTC and by the IRIS platform of ICube.

References. [1] Muthupillai *et al.* 1995, *Science* 269(5232):1854-7; [2] Pagé *et al.* 2019, *JMRI* 50(6) :1982-9; [3] Tang *et al.* 2022, *JMRI* 56:712-4; [4] Klein *et al.* 2014, *PLOS ONE* 9(3): e92582; [5] Chatelin *et al.* 2015, *JCBFM* 36(5):954-64; [6] Qin *et al.* 2013, *JMRI* 56(3): 712-24; [7] Knutsson *et al.* 1994., *Proc. of 1st Int. IEEE Conf. on Img. Process.*

Contact: schatelin@unistra.fr (S. Chatelin)