Between-visit reproducibility of shear wave viscoelastography for diffuse liver disease

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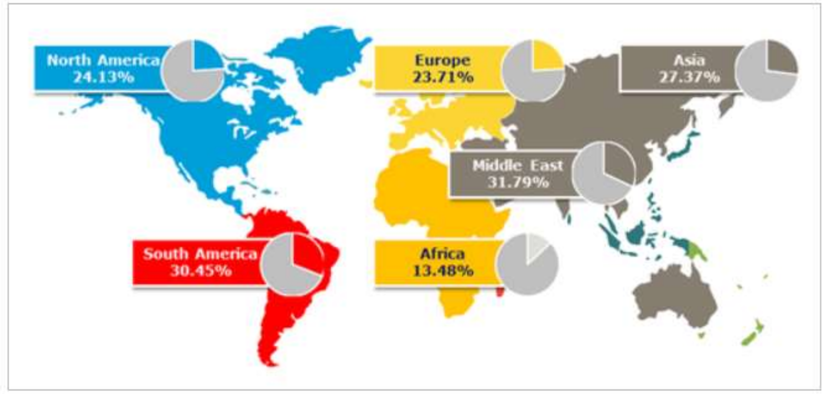
Introduction: Liver disease

Non Alcoholic Fatty Liver Disease(NAFLD)

Prevelance



- In humans, the natural history leading from nonalcoholic fatty liver disease (NAFLD) to nonalcoholic steatohepatitis (NASH) is not completely understood; hence, there is a need to improve the noninvasive characterization of the fatty liver disease spectrum to improve diagnosis and prognosis of NAFLD.
- Accurate assessment of the degree of liver fibrosis is important for estimating prognosis and deciding on an appropriate course of treatment for cases of liver disease.(WK Jeong,2014).
- As diseases stage increases, **changes in tissue stiffness** occurs (N. Frulio-2013).

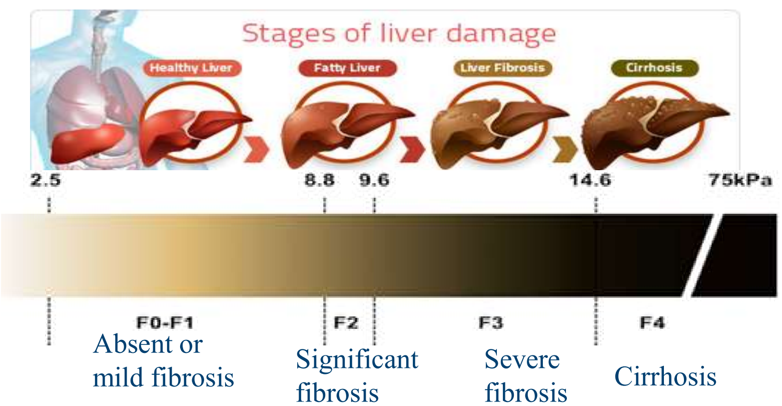


Fig: The stages of liver disease classification using current clinical markers and its correlation with young's modulus are shown here.

Courtesy: Francesco Paparo et al.,

Fig: For diagnosis of liver fibrosis, biopsy is still considered as the gold standard method and widely used in clinical practice

- Invasiveness
- Physical and mental discomfort to the patient.
- Very small size of samples obtained through biopsy may not represent a disease condition .
- Not suitable for treatment follow-up
- Sampling error, and Cost

Courtesy: Woo et al. 2014

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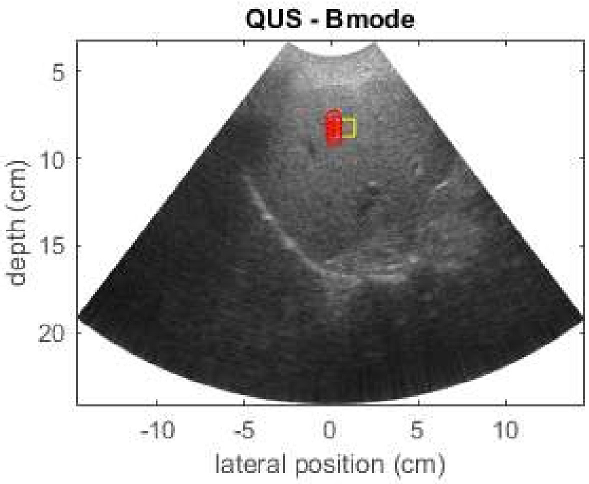
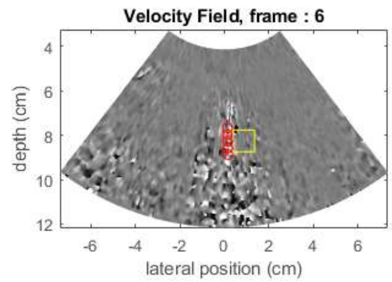
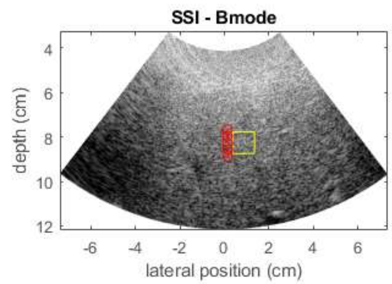
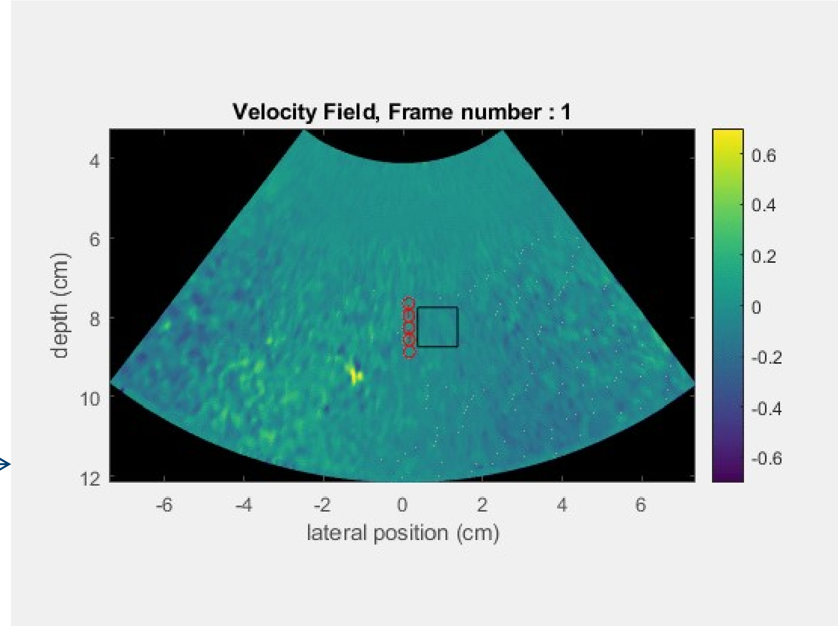
Methods









Multi-parametric shear wave elastography

- Shear wave speed(C)
  - Velocity field (2-D auto corrélation algorithm)(Lopas at al., 1995)
  - ROI 1cm x 1cm 0.5mm from push location
  - Shear Wave Speed(SWS)(Deffieux et al.,2009)

- Viscoelasticity parameters
  - Stiffness (Young's modulus $Y = 3\rho c^2$)
  - Viscosity ($\eta = \frac{G''}{\omega}$)
  - Viscoelasticity ($G = G' + iG''$)
- SW Dispersion: SWS is frequency dependent measure, the dispersion was assessed as its slope vs frequency. (Barry et al. 2012; Parker et al., 2015).
- SW Attenuation(Bernard et al.,2016).
  - Frequency shift method.

1. M. Bhatt, L. Yazdani, F. Destrempes, L. Allard, B. Nguyen, A. Tang, and G. Cloutier, "Multiparametric *in vivo* ultrasound shear wave viscoelastography on farm-raised fatty duck livers". **Poultry Science**, 100(4) ,100968, 2021.
2. M. Gesnik, M. Bhatt, M.H. Roy-Cardinal, F. Destrempes, L. Allard, B. N. Nguyen, T. Alquier, J.F. Giroux, A. Tang, and G. Cloutier, "*In vivo* ultrafast quantitative ultrasound and shear wave elastography imaging on farm-raised duck livers during force feeding". **Ultrasound in Medicine and Biology**, 46(7), 1715-1726, 2020.
3. S. Bernard, S. Kazemirad and G. Cloutier, "A Frequency-Shift Method to Measure Shear-Wave Attenuation in Soft Tissues," in IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 64, no. 3, pp. 514-524, March 2017, doi: 10.1109/TUFFC.2016.2634329.

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Results

Patient 1, Visit 1

A) B) C)

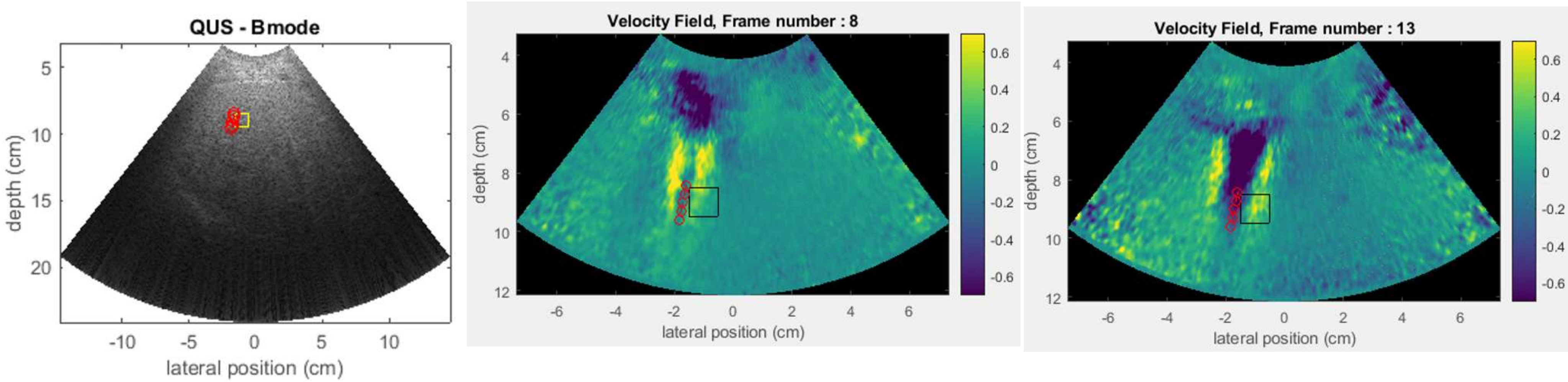

Figure shows Patient 1, Visit 1, A) a B-mode image of a NASH patient, B&C) the SW velcity field, where the red-circle indicates the SW push location, and the yellow-square ROI measurements made next to the SW push.

Patient 1, Visit 2

A) B) C)

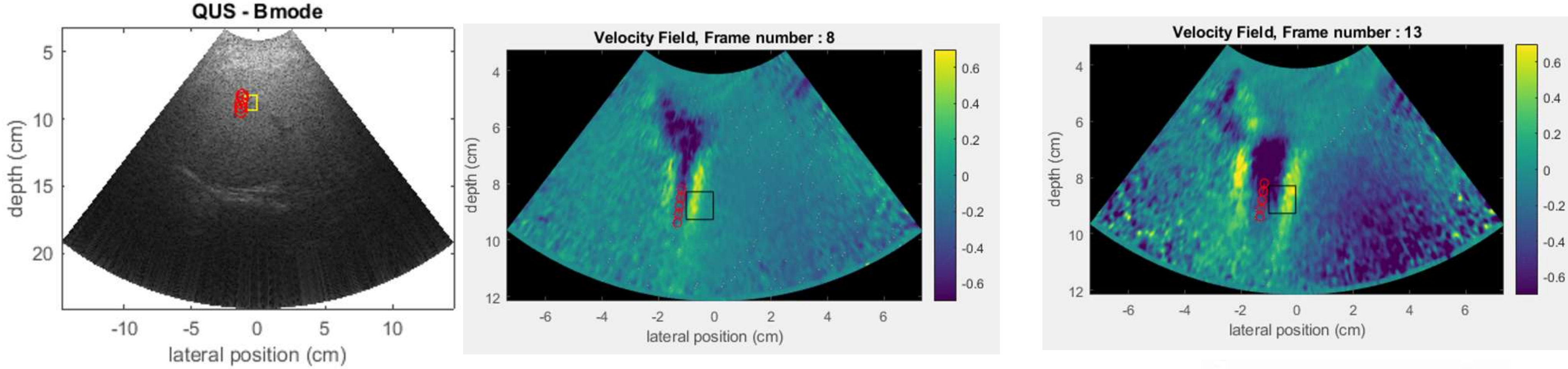

Figure shows Patient 1, visit 2, A) a B-mode image of a NASH patient, B&C) the SW velocity field, where the red-circle indicates the SW push location, and the yellow-square ROI measurements made next to the SW push.

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Results

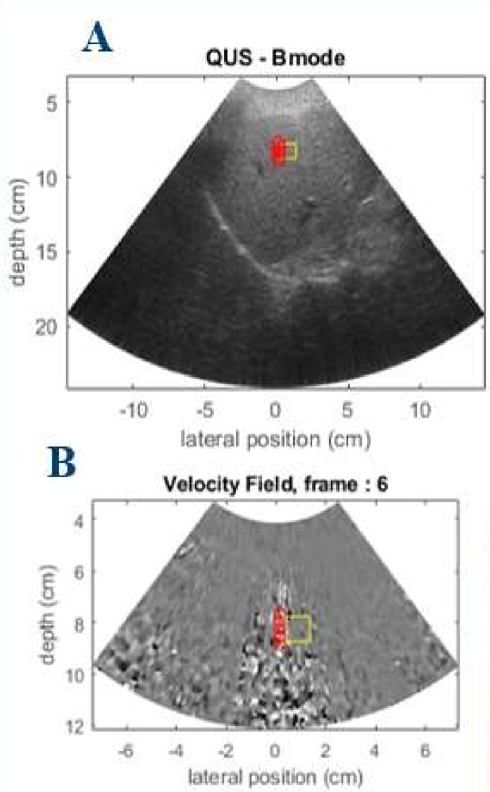

Figure.1

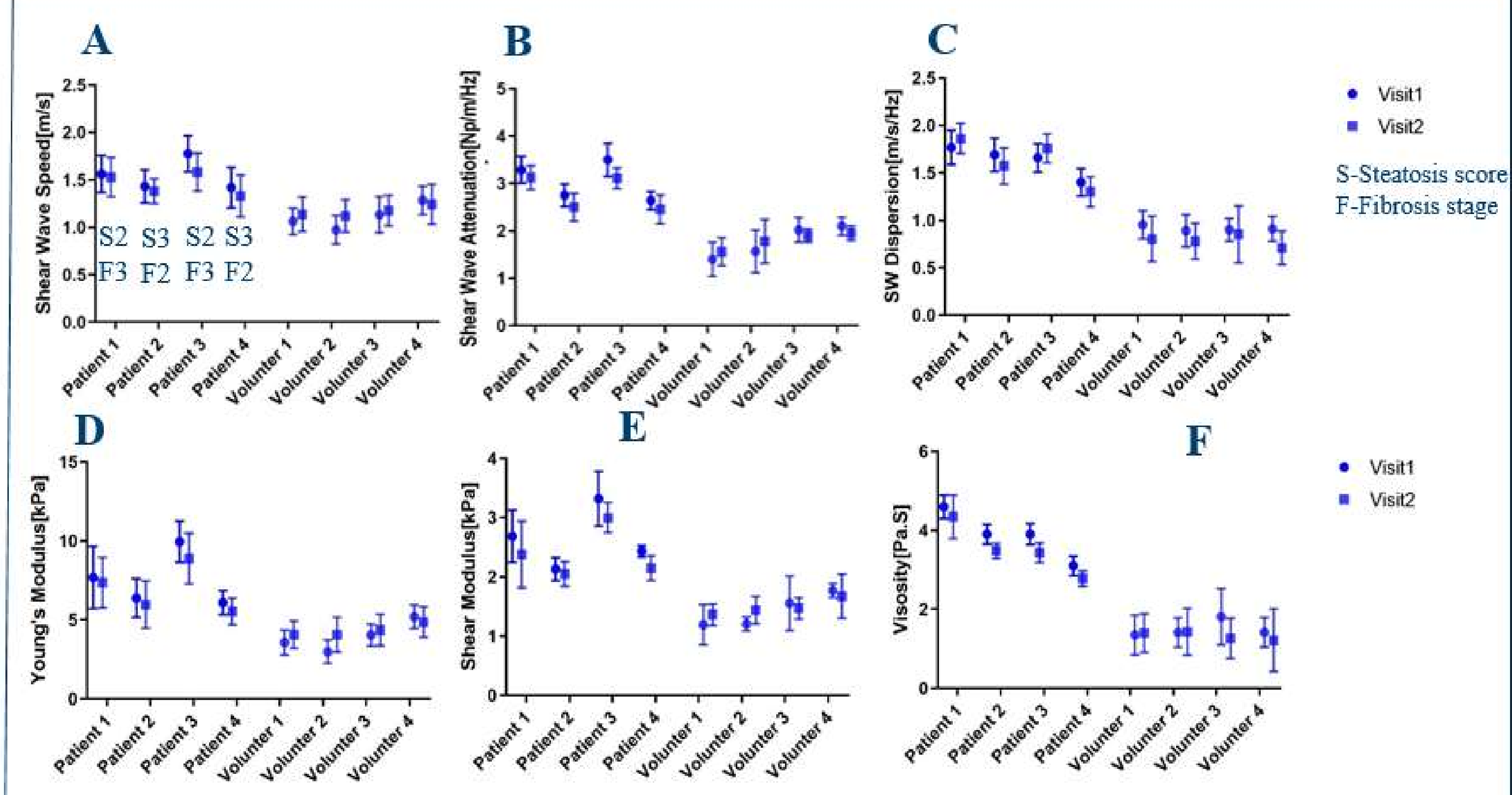

Figure.2

Examples of a B-mode image and the generated SW velocity field within the liver of a human subject are displayed in Fig. 1. The red circle indicates the ultrasound push location, and the yellow square gives the region of interest where SW propagation was analyzed.

Figure 2 shows viscoelastic measurements (mean ± SD, n = 10 acquisitions) for both populations. Figure 2.A. shows biopsy results of patients (S: Steatosis grade, F: fibrosis stage). Measurements were consistent and reproducible between the two visits, thus strengthening the potential of SW viscoelastography for the diagnosis and treatment follow-up of diffuse liver disease in human patients. Further validation is ongoing on a larger cohort.

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