IN VIVO ASSESSMENT OF ABDOMINAL MUSCLES APPARENT ELASTICITY DURING CONTRACTION
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Introduction
Numerical models are currently considered as research tools to help improving the treatment of hernia ted patients. Past in-vivo studies on abdominal muscles have mainly focused on muscle geometry in several postures or during exercises [Brown, 2010]. Mechanical properties are also needed for models and muscle activity must be taken into account. Surface EMG may not be appropriate to quantify the activity of the 3 layers of lateral muscles. Moreover it would be difficult to obtain a maximal contraction data needed to normalize the muscular activity from herniated patients. Shearwave elastography [Bercoff, 2004] has been recently used to characterize limb muscles [Nordez, 2010] and have shown a link between muscle stiffness and activation. In the current study, the method was applied to study the abdominal muscle apparent elasticity in two contractive states.

Methods
Data were collected on 11 healthy volunteers (8 males and 3 females) aged from 40 to 62 (ethical committee approval B110676-90). The subjects were seated and data was collected during 3 tasks: (1) rest, (2) pullback load near the shoulders (3) Valsalva maneuver. Elastographic images were collected using an Aixplorer ultrasonic scanner with a SL10-2 probe (Supersonic Imagine, Aix-en-Provence, France). Images were centered on the right rectus abdominus (RA, horizontal and vertical directions) and on the lateral muscles (external obliquus EO, internal obliquus IO, transverse abdominus TrA, in horizontal, vertical and oblique directions). Mean apparent elastic modulus and thickness of each muscle were computed from the images. EMG electrodes were used on the RA and EO.

Results
Results do not show significant changes of the muscle thickness with tasks. Significant differences were found for the apparent elasticity of the OE, IO and TrA between Valsalva and the other tasks. During pullback loading, only the RA were working, while all lateral muscles and the RA were contracted during Valsalva. The pattern for the RA was dependent on the direction (Figure 1).

Discussion
Elasticity seems sensitive to both deep and superficial muscles activity. The approach is also sensitive to the tissue anisotropy. During pullback loading, the RA are mostly stretched in the vertical direction, leading to a higher apparent elasticity in the vertical direction (w.r.t. rest). During the Valsalva’s maneuver, the lateral muscles are also contracted. They stretch the RA in the horizontal direction which could explain the difference between Valsalva and rest or pullback in the horizontal direction. Applications of the results for human modelling are ongoing and an application of the protocol to patients is under preparation.

References