# IN VIVO SUCCION MEASUREMENTS OF YOUNG'S MODULI: APPLICATION TO HUMAN ABDOMINAL SKIN AND FAT

**Nathanaël Connesson (1), Yohan Payan (1)**

1. *Univ. Grenoble Alpes, CNRS, UMR 5525, VetAgro Sup, Grenoble INP, TIMC, 38000 Grenoble, France*

## Introduction

The *in vivo* and *in situ* mechanical characterization of living soft tissue presents challenges [1], even for properties as Young's modulus. The VLASTIC method, based on succion, has been developed to evaluate elasticity moduli of bilayered soft tissue structures using only surface measurements [2]. Measurements are performed with various aspiration diameters to load the material at different depths. This provides information to evaluate the upper and lower material's Young moduli. This method is applied here to evaluate *in vivo* the human skin and fat Young's moduli of human abdomen. In particular, this work challenges the method repeatability and capacity to provide patient specific mechanical properties.

## Methods

The skin and underneath fat Young's moduli of 3 healthy volunteers are evaluated experimentally on the abdomen with aperture diameters from 4 to 30 mm. Four repeatability tests are also performed onto the first volunteer over more than 1 year. These data sets allow for a comparison between the repeatability of the method identification and the differences observed among the volunteers.

## Results and Discussion

Visual inspection of the raw measurement (Pressure-Tissue volume slopes) indicates satisfactory test conditions (figure 1).

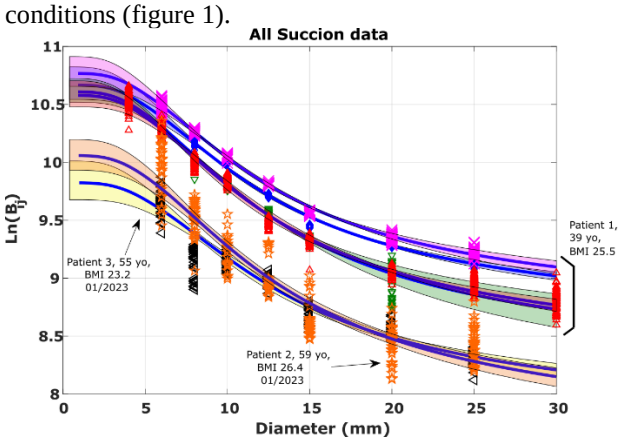


*Figure 1: Raw succion results: Slope Bij of the Pressure-Normalized Tissue Volume for the 3 volonters and 4 reproducibility tests on volonter 1.*

Volunteer 1 experimental set of curves is visibly different from volunteers 2 and 3. Yet, the repeatability proves to be uneven onto volunteer 1: the experimental Pressure-Tissue volume slopes do not perfectly overlap.

These observations are confirmed after performing the inverse identifications (figure 2a and b). For volunteer 1, the skin Young's modulus is repeatably identified within the identified indifference regions (45 to 70 kPa) and is visibly different from the skin Young's moduli of volunteer 2 and 3 (20 to 35 kPa). The repeatability is yet not fully satisfactory for the fat Young's modulus measurement (3 to 7 kPa) and is uncorrelated with time differences. Volunteers 2 and 3 fat mechanical properties seems lower (1.8 to 3 kPa).
A larger repeatability test cohort would be required to confirm these observations.

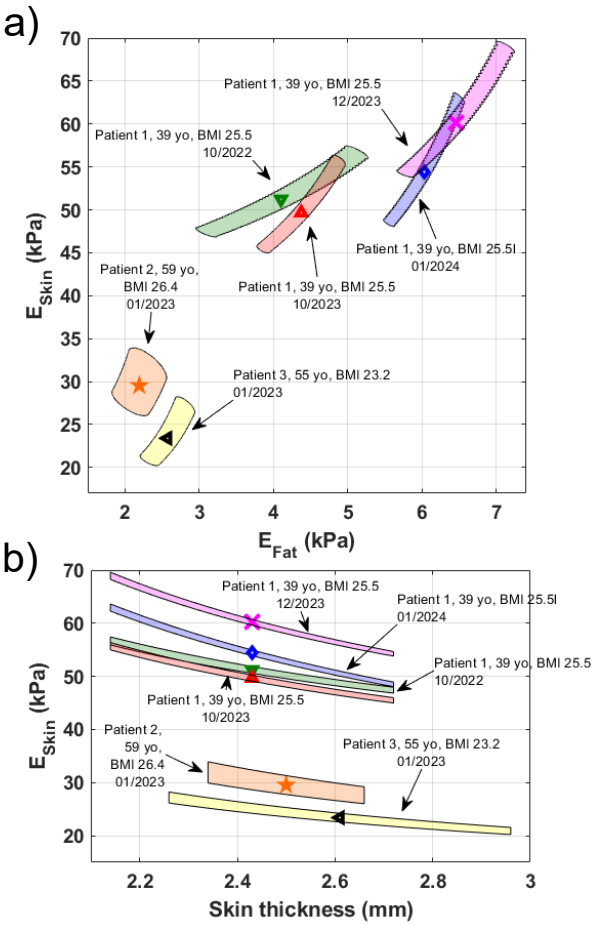


*Figure 2: a) Inverse identification of the skin and fat Young's moduli $E_{Skin}$, and $E_{Fat}$. b) Skin thickness mean and range (Mean±2Std) measured by ultrasounds and its incidence on the identified skin Young's modulus.*

## References

1. Weickenmeier et al, J of Biomechanics, 46-16:4279-4286, 2015
2. Connesson et al, Experimental Mechanics, 63:715-742, 2023