An Opto-Mechanical Device for the Local Characterization of the Human Skin *in vivo*

Sylvain JOLY[a], El KhansaREKIK[a], Emmanuelle JACQUET[a], Jérôme CHAMBERT[a], Bruno WACOGNE[a], Patrick SANDOZ[a],
[a]Institut FEMTO-ST, Université de Franche-Comté, CNRS UMR6174, 25000 Besançon, France

Introduction

To improve disease diagnosis and optimize treatment, a patient-specific approach is often required. In this aim, we develop new opto-mechanical tools offering a multi-modal characterization of the human skin *in vivo*. The foreseen device includes both mechanical and optical modalities. The purpose of the optical part (yet under development) is to assess the skin composition at a microscopic scale thanks to an imaging probe based on white light and fluorescence techniques .The mechanical part allows servo-controlled mechanical loading of the skin with the simultaneous acquisition of the displacement and strain fields up to the cm-scale. The information obtained enables the modelling of the skin's response to complex mechanical loadings. Such data are useful for designing adequate cutaneous substitutes.

The paper deals mainly with the mechanical part.

Methods

To determine the skin mechanical parameters *in vivo*, an ultra-light uniaxial extensometer was developed. It is made of two mobile tabs stuck on the skin with surgical glue and translated in 1D by servo-controlled actuators with respect to an ultra-light frame. Unlike Boyer et al. [1], the weak device mass (36 g) allows to perform tests without external fixation, even if the skin is not under tension. Moreover, the force measure tabs are surrounded by protection tabs to prevent from disturbing side effects [2]. The rigidity of the static frame is considered as infinite with respect to skin's one.

The device is equipped with high sensitivity displacement and load sensors. Actuation and measurements are synchronously driven by a friendly user interface developed on Labview®. Servo-control can be made either in force or displacement. Load and unload sequences are freely programmed with a maximum speed of about 1 mm/s.

Skin displacement fields are detected in parallel to actuation thanks to an imaging module using an open source Matlab® software developed by Eberl et al. [3] for performing Digital Image Correlation (DIC).

Results

After device calibration and validation through reference tests, diverse input commands (controlled either in force or displacement) can be applied to the human skin *in vivo*. Incremental, creep, relaxation tests under quasi-static or harmonic loading are thus allowed. The obtained force-displacement data can then be converted into stress-strain data from complementary measurements of the local skin thickness.

Displacement fields provided by the DIC method demonstrated the efficiency of the protection tabs to keep measurements free from interferences due to surrounding skin. The extension test performed is thus analogous to a traction test.

Conclusions and prospects

A mechanical device is presented for the identification of patient-specific *in vivo* skin parameters and mechanical behaviour law from uniaxial extension tests. A similar biaxial device is under development to address more complex loadings. The complementary optical module under development consists in acquiring sets of small sized but highly resolved images in both white light and fluorescence. Further image processing will reconstruct wide fields, and high resolution images from these complementary data sets will correlate optical data with mechanical ones. The complete device is being developed in accordance to clinical use requirements.

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