Title:

3D VOCAL-FOLD FIBROUS MICROSTRUCTURE: EXPERIMENTAL CHARACTERIZATION BY SYNCHROTRON X-RAY MICROTOMOGRAPHY AND MECHANICAL MODELING

Presenters:

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Abstract:

Since the last decades, the development of fundamental knowledge on mechanics and multi-physics phenomena driving biological systems has enabled the outstanding improvement of biomaterials able to mimic the mechanical behaviour of human soft tissues. Vocal-fold tissues are very challenging to replace as they possess specific abilities to endure large reversible deformations and to vibrate up to more than thousand cycles per second. Such unique performances result from complex physical and biomechanical features which remain poorly understood so far. This is mainly ascribed to a lack of knowledge of their unique macro- and microstructures, very difficult to investigate experimentally [1,2]. The 3D characterization of each constitutive element at the micrometric scale is a current challenge using confocal microscopy (limited depth of field), micro-IRM (limited spatial resolution) or X-ray microtomography in absorption mode (low sensitivity to distinguish fresh biological components owning similar absorptive properties).

The present work aims (i) at characterizing the 3D microscale arrangement of the vocal-fold tissue on excised anatomical samples by means of X-ray synchrotron phase-contrast microtomography; (ii) at studying the relationship between 3D microstructure and vocal-fold biomechanical behaviour using a multiscale modeling approach.

Regarding the experimental part, 7 human larynges have been scanned at mean (12.3µm) and high-resolution (0.65µm), using X-ray microtomographs of the ESRF's ID19 beamline. Histological colorations have allowed a comparative analysis of the acquired images using optical microscopy. A morphological and histological database will be presented, quantifying the 3D geometries, orientations and densities of vocal-fold fibrous structure. In agreement with the histological analyses, the striated-cells network of inferior thyroarytenoid muscle (*vocalis*) has been differentiated from the fibrous network of *lamina propria* (type-I and type-III collagen fibers, elastin fibers).

Regarding the theoretical part, a recent 2D micro-mechanical model of the vocal folds [3] has been improved to account for the 3D fibrous networks of the tissue. The impact of several microstructural parameters (fiber-bundles initial diameter, waviness and orientation) on the vibro-mechanical response of the tissue has been evidenced.

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