Frequency analysis of ex-vivo porcine vocal fold elasticity using pipette aspiration

Florian Scheible[1]*, Raphael Lamprecht[1], Marion Semmler[2], Michael Döllinger[2] and Alexander Sutor[1]

[1]Institute of Measurement and Sensor Technology, UMIT - Private University, Hall i.T., Austria
[2]Div. of Phoniatrics & Pediatric Audiology, Dep. of Otorhinolaryngology, University Hospital Erlangen, Germany

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Introduction

To understand the complex process of phonation, it is necessary to know not only the static material properties of the tissue, but also the frequency depended.
In material properties studies of vocal folds pipette aspiration is a common tool, for dynamic measurements to observe its variation with frequency [1-3].

Methods

Figure 1 shows the measurement setup with the used pipette, which is pressed at the middle of the antero-postero line of one porcine vocal fold (VF), with a certain force, estimated by a load cell. A speaker produced sinusoidal pressure exciting the tissue and its velocity is determined by a vibrometer laser beam that permeates through the pipette.Conclusively, the absolute deformation is calculated by integration. A calibrated microphone is measuring the exact pressure.

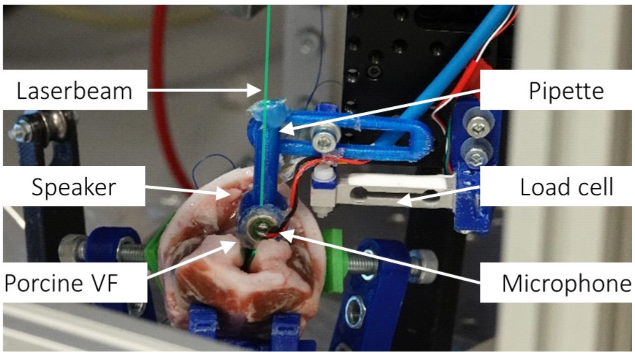

Figure 1: Measurement setup on porcine VF. Pressure produced by a speaker forces the sample to oscillate. The movement is detected by a laser vibrometer, as well as the pressure difference by a microphone.

Frequencies from 150 Hz to 1 kHz were produced with a step width of 50 Hz, and three different pressure amplitudes, each increasing up to 9, 14 and 19 Pa. Whereas each iteration is repeated six times. The pressure and velocity peak height of each frequency is determinate through a FFT over the signal length of one second. The measurement process is repeated after 13 min and 20 h to study the impact of temperature and humidity on the elasticity.The elasticity $\boldsymbol{E}$ is calculated with the following formula the pressure difference $\Delta\boldsymbol{p}$ is devided by the absolute displacement $\Delta\boldsymbol{d}$

$$E = C\,\frac{\Delta p}{\frac{\Delta d}{di}}, \qquad (1)$$

with the pipette diameter di and a coefficient C dependent on the wall thickness [4].

Results

In Figure 2 the elasticity over the frequency for each pressure amplitude is shown as crosses. For each measurement (initial, after 13 min, after 20h) the mean value of the elasticity between the pressure amplitudes is plotted.

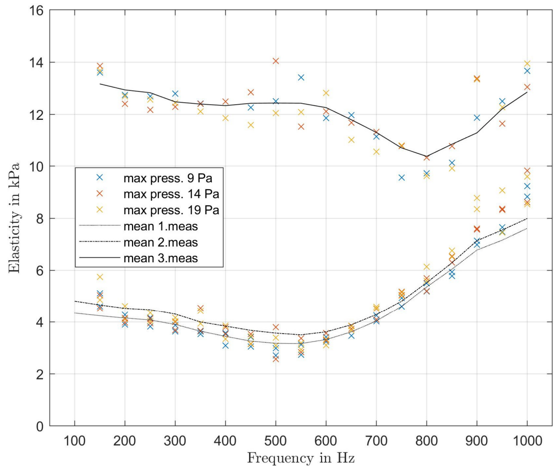

Figure 2: Elasticity with three different pressure amplitudes for each measurement (x), and the mean values (lines).

The first two measurements show the same characteristic, but the second measurement shows an increased elasticity $\boldsymbol{E}$ 8.26% (average over all Frequency) which can be explained by tissue dehydration. The third measurement after 20 h shows a different behavior with much higher values.

Discussion

To our knowledge, until now there are no ex-vivo measurements, to which our measurements could be validated.
Further investigations are planned to study variance in natural tissue and the effect of temperature and humidity of the tissue. Like previous investigations at our institute the frequency dependency of the elasticity will be determined with inverse numerical simulations [3].

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References

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**florian.scheible@umit.at*