DELIVERABLE REPORT

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1) Scope of the document

Scope of this document is to report the description of the measurements performed on healthy subjects and their results as a short summary. A more detailed version is available upon request.

2) Summary

In this document, we report the preliminary results related to ten healthy volunteers/controls (5 female, aged 27-47 years with a mean of 35.5).

Protocol

Subjects have been measured by expert clinicians guided by ultrasounds images. The patients were positioned in a supine position during the whole process. Once the tissue to measure is highlighted by US images, the probe is maintained still by a mechanical arm during the optical data acquisition. We note that we attempt to minimize the overlying skin and muscle thickness by adjusting the neck position. The probe is applied in a way to optimize both the ultrasound imaging and the optical imaging.

The standard protocol adopted for the LUCA optical measurements in each subject consisted in the measurement of four locations of the neck. The locations considered are: right thyroid lobe (location 1), right sternocleidomastoid muscle (location 2), left thyroid lobe (location 3), and left sternocleidomastoid muscle (location 4). The measurements on each location have been repeated twice. Each acquisition took approximately 120 seconds during which we have acquired five repetitions of eight TRS measurements and sixty auto-correlation curves of DCS for optics and an ultrasound image every five seconds.

Data analysis

The analysis of the ultrasound images acquired simultaneously to the optical measurements allowed us to retrieve the depth of the tissue of interest (i. e. healthy thyroid lobe, muscle).

The preliminary data analysis of the optical measurements has been performed using the diffusion approximation to model the photon propagation in the tissue for both for TRS and DCS considering a homogeneous semi-infinite medium [1,2,3].

DCS: In general, the LUCA DCS curves acquired are characterized by a good signal-to-noise-ratio, in spite of the high absorption shown by the thyroid tissue [3]. This is made possible by the 16 channel detection system of LUCA DCS module.

Challenges and future improvements: The presence of a thick and highly absorbing superficial layer (muscle) makes difficult the retrieval of the physiological parameters of deeper tissue regions. In this respect, the use of both short and long distance measurements (use of a bi-layer model and/or two steps approach etc.), and the use of numerical (not analytical) fitting procedures will now be considered.

TRS: From a technical point of view (signal to noise ratio level etc.), the TRS measurements can be considered good. For TRS analysis the eight wavelengths have been considered globally. Indeed, a spectral constraint has been applied on the reduced scattering, by fitting the a e b coefficients of the Mie law. Also for the component concentrations a global fit has been applied. On the basis of the absorption spectra of deoxy-hemoglobin, oxy-hemoglobin, lipids, collagen and water content, the concentrations of these chromophores have been retrieved simultaneously. A separate fit has been performed to retrieve the absorption coefficient at different wavelengths of the tissue measures.

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Challenges and future improvements: This preliminary analysis is affected by an instability and a strong dependence on initial fit parameters. Furthermore, the high absorption and the presence of a thick layer (muscle) over the thyroid cause further fitting problems. As for the DCS data analysis, an improvement in the analysis procedures has to be done.

***In vivo* preliminary results**

Here below we report a summary of the results obtained with the preliminary data analysis. We present the average values over all the healthy population of the principal physiological parameters, as blood flow index (BFi), oxygen saturation (StO_2 , oxy-hemoglobin divided by total hemoglobin), total hemoglobin concentration (THC, sum of oxy- and deoxy-hemoglobin concentrations), water concentration (H_2O), collagen concentration and lipid concentration, measured in the four different location considered by the LUCA measurement protocol. The preliminary data reported here below are in agreement with the previous characterization of the healthy thyroid published by Lindner et al. [3].

Tissue anatomy, i.e. depth:

	Depth All (mm)	**Depth Males (mm)**	**Depth Females (mm)**
Thyroid right	8.7 ± 2.4	10.2 ± 2.6	7.3 ± 1.2
Muscle right	3.1 ± 0.7	3.4 ± 0.8	2.8 ± 0.6
Thyroid left	8.2 ± 2.2	9.6 ± 2.1	6.8 ± 1.3
Muscle left	3.1 ± 0.8	3.3 ± 1.0	2.9 ± 0.5

Physiological parameters:

	BFi ($x10^{-9}$ cm^2/s)	**StO2 (%)**	**THC (µM)**	**H2O (mg/cm^3)**	**Collagen (mg/cm^3)**	**Lipid (mg/cm^3)**
Thyroid right	11.5 ± 6.6	78 ± 9	98 ± 43	429 ± 190	475 ± 219	394 ± 429
Muscle right	3.9 ± 1.7	74 ± 7	90 ± 31	482 ± 166	468 ± 163	321 ± 426
Thyroid left	11.6 ± 4.6	74 ± 6	89 ± 50	484 ± 152	448 ± 212	686 ± 435
Muscle left	3.7 ± 1.0	76 ± 6	89 ± 30	492 ± 177	495 ± 166	304 ± 410

3) Conclusions

We have reported a preliminary data analysis of the first 10 healthy subjects measured through the LUCA device. The data acquired resulted of a good quality, in spite of the high absorption of the thyroid tissue, which tends to reduce the signal-to-noise-ratio of the measurements. The results are in agreement with previous literature [3]. A more detailed report of the results is available upon request.

[1] T. Durduran et al., Reports on Progress in Physics, 73(7):076701, 2010

[2] R. C. Haskell et al., Journal of the Optical Society of America A 11, 2727, 1994

[3] C. Lindner et al., PLOS ONE 11, e0147851, 2016

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