Ultra High Resolution Optical Coherence Tomography in Laryngology

Aspects of development
2 parts: background and future

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Advances in Cellular and Molecular Otolaryngology

co-action PUBLISHING

POSITION PAPER

Optical coherence tomography in the laryngeal arytenoid mucosa for documentation of pharmacological treatments and genetic aspects: a protocol

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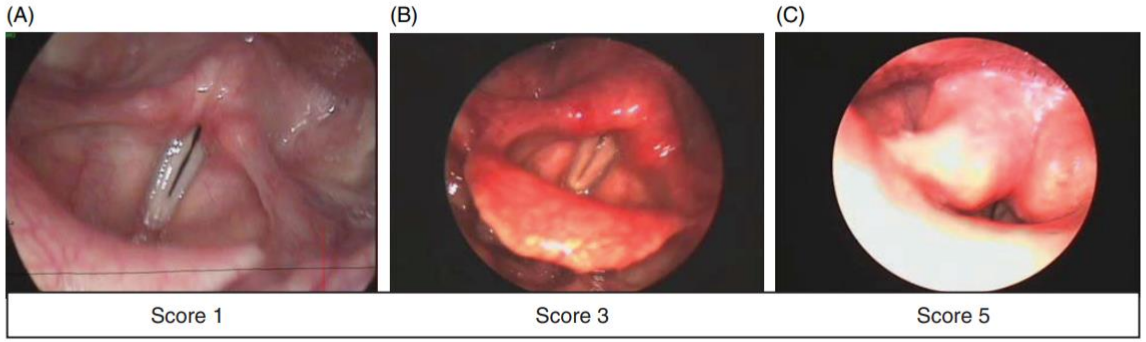
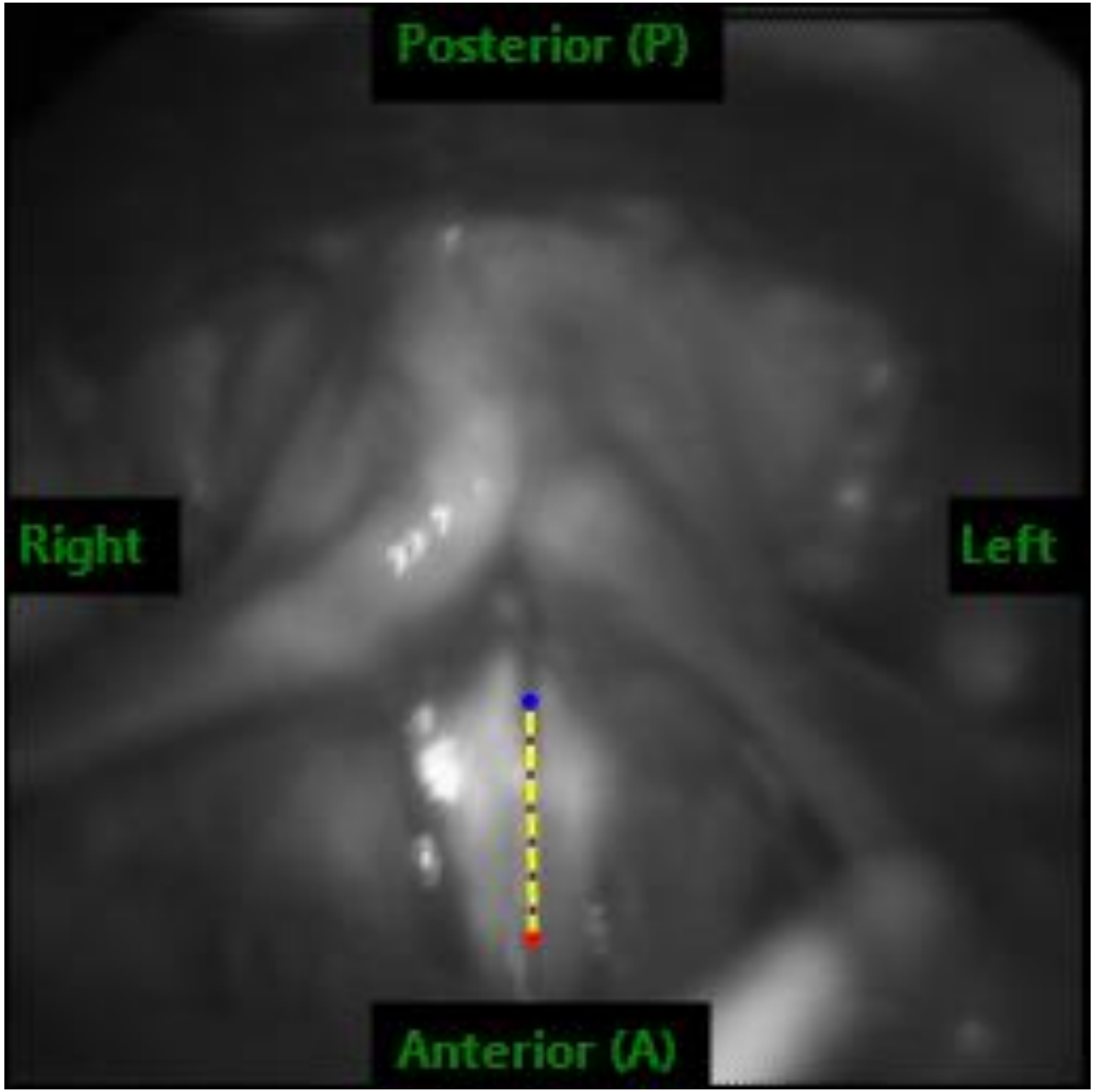
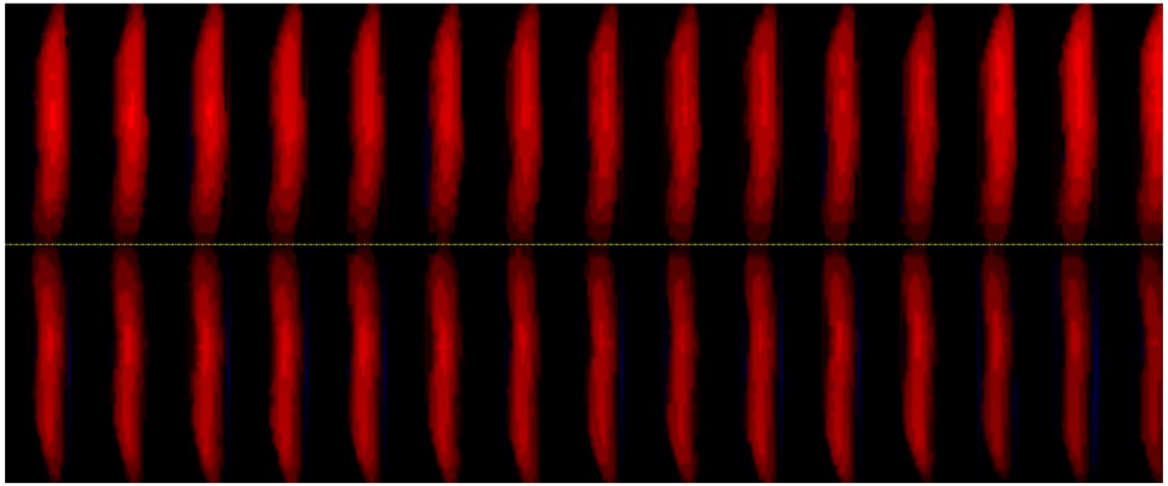
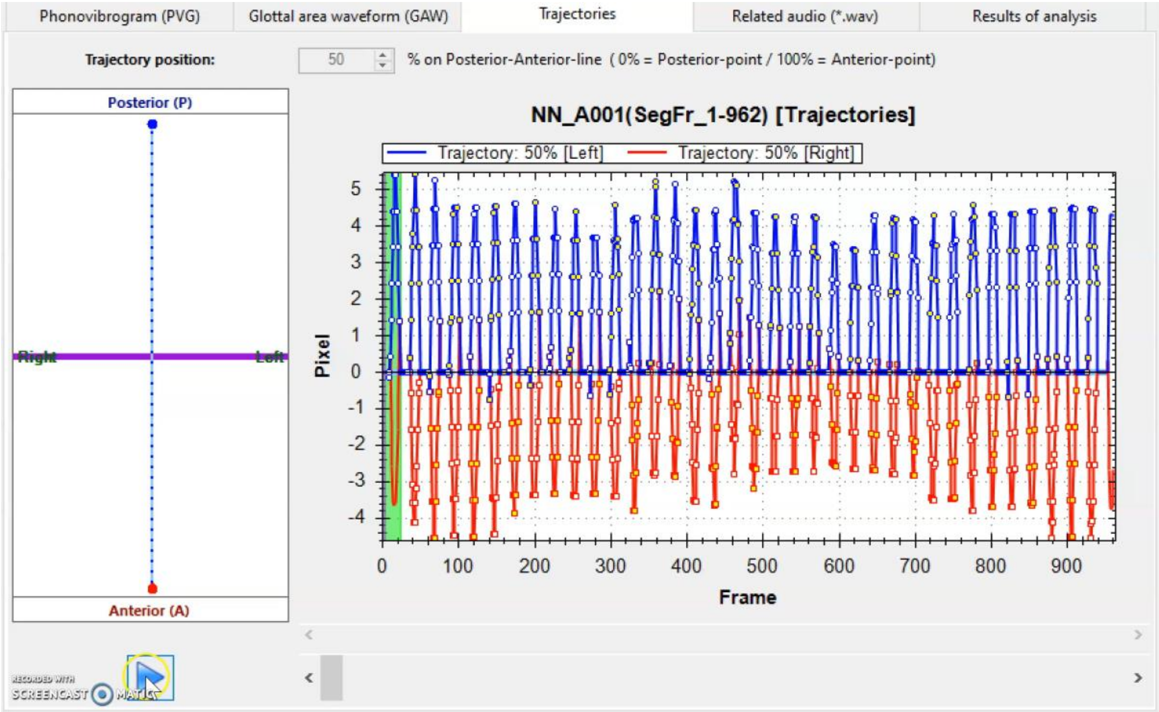
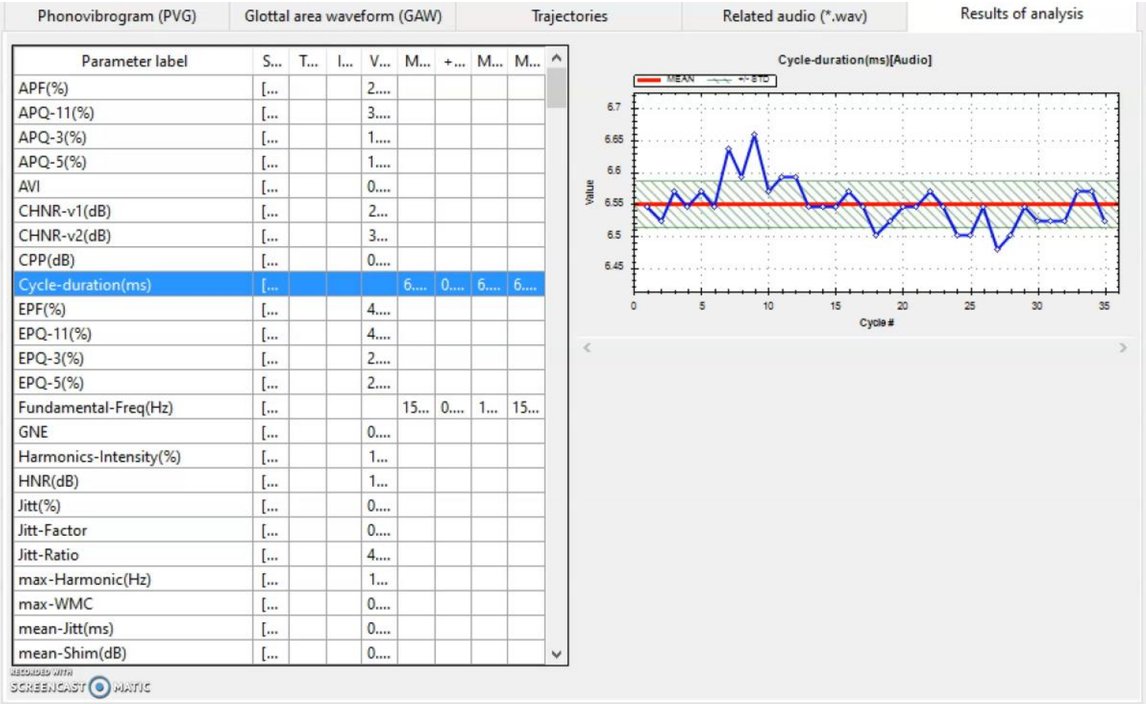


Fig. 1. High-speed film scores with 4,000 pictures/sec of the larynx including the arytenoid regions. Score 1 indicates a normal arytenoid region and normal vocal folds. Score 3 indicates a moderate oedema of the arytenoid region and normal vocal folds. Score 5 indicates almost total closure of the larynx due to arytenoid oedema (4).


Posterior (P)
Right
Left
Anterior (A)




Phonovibrogram (PVG)
Glottal area waveform (GAW)
Trajectories
Related audio (*.wav)
Results of analysis
Trajectory position:
50
% on Posterior-Anterior-line (0% = Posterior-point / 100% = Anterior-point)
Posterior (P)
Right
Left
Anterior (A)
NN_A001(SegFr_1-962) [Trajectories]
Trajectory: 50% [Left]
Trajectory: 50% [Right]
Pixel
Frame
0
100
200
300
400
500
600
700
800
900
5
4
3
2
1
0
-1
-2
-3
-4


Phonovibrogram (PVG)
Glottal area waveform (GAW)
Trajectories
Related audio (*.wav)
Results of analysis
Parameter label
APF(%)
APQ-11(%)
APQ-3(%)
APQ-5(%)
AVI
CHNR-v1(dB)
CHNR-v2(dB)
CPP(dB)
Cycle-duration(ms)
EPF(%)
EPQ-11(%)
EPQ-3(%)
EPQ-5(%)
Fundamental-Freq(Hz)
GNE
Harmonics-Intensity(%)
HNR(dB)
Jitt(%)
Jitt-Factor
Jitt-Ratio
max-Harmonic(Hz)
max-WMC
mean-Jitt(ms)
mean-Shim(dB)
Cycle-duration(ms)[Audio]
MEAN
Value
Cycle #

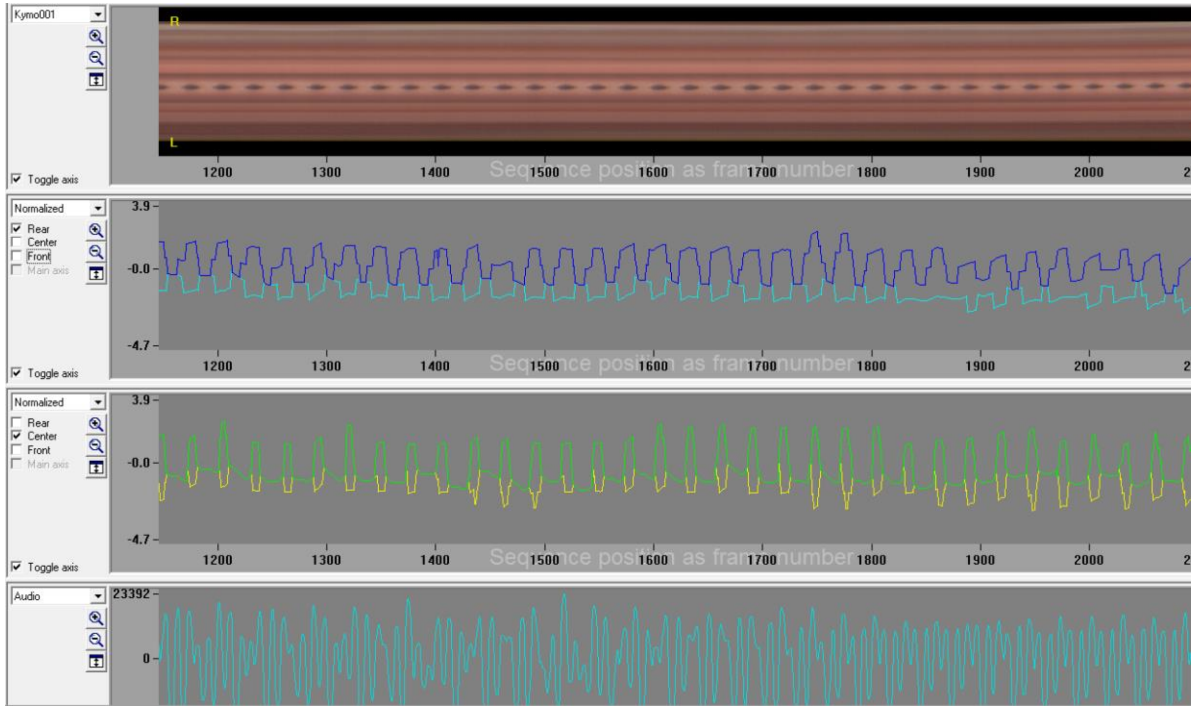
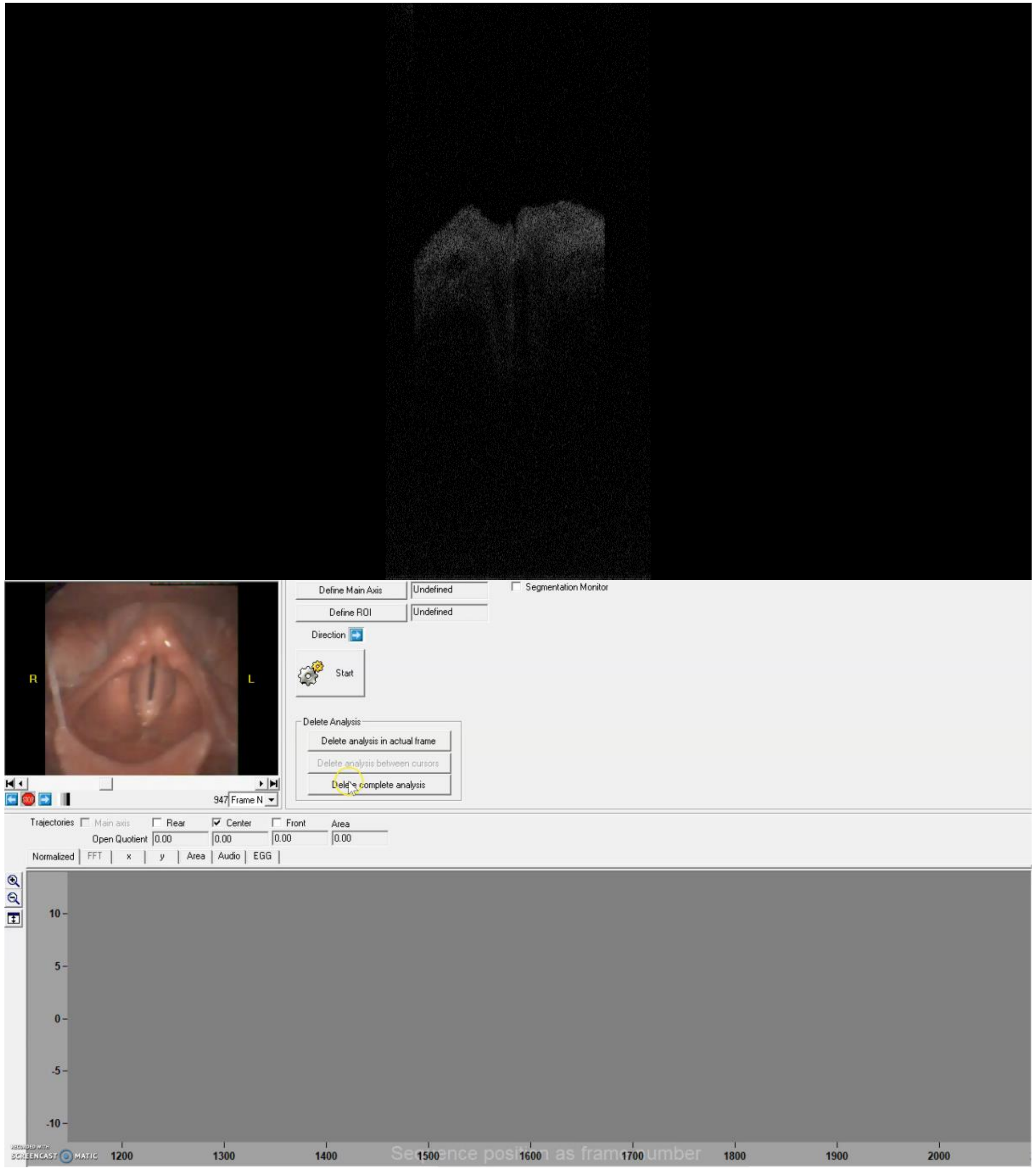

Kymo001
Toggle axis
Normalized
Rear
Center
Front
Main axis
Audio
3.9
-0.0
-4.7
23392
0
1200
1300
1400
1500
1600
1700
1800
1900
2000

Figure 1 : OCT hand piece.

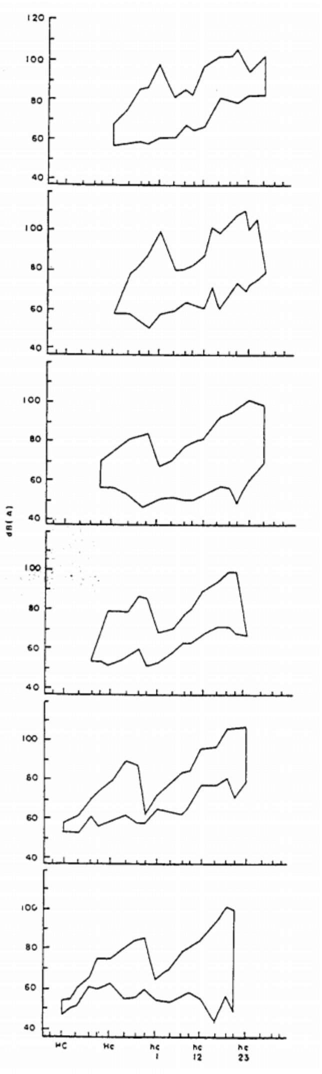
From: In vivo cross-sectional imaging of the phonating larynx using long-range Doppler optical coherence tomography

The OCT device mounted concurrently with a rigid laryngoscope.

Carolyn A. Coughlan, Li-dek Chou, Joseph C. Jing, Jason J. Chen, Swathi Rangarajan, Theodore H. Chang, Giriraj K. Sharma, Kyoungrai Cho, Donghoon Lee, Julie A. Goddard, Zhongping Chen & Brian J. F. Wong



Die biologische Entwicklung der Stimme in der Pubertät



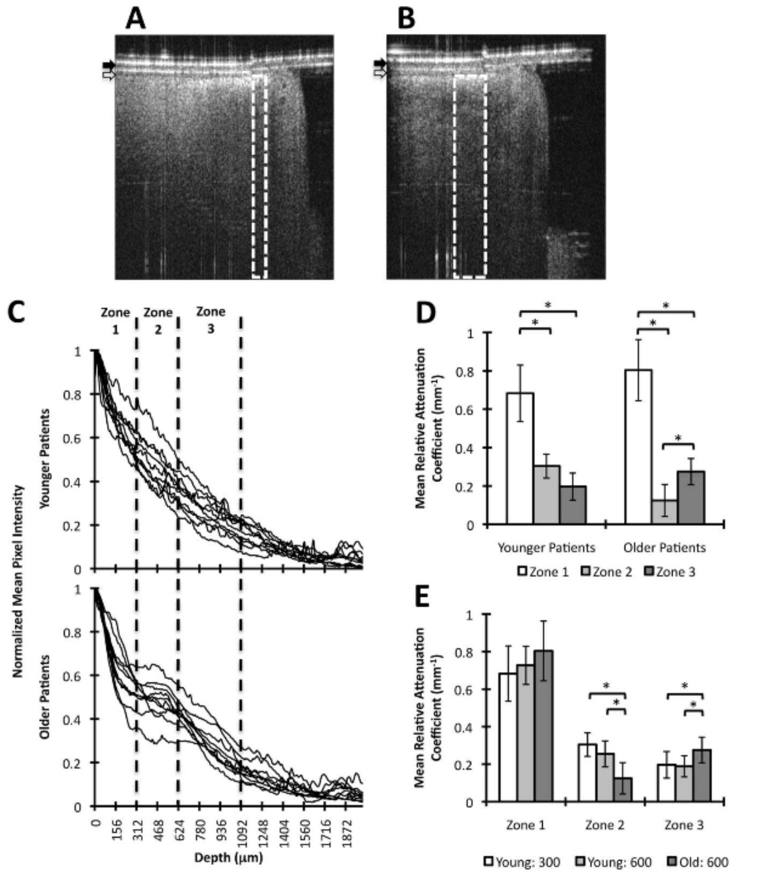


Fig. 3. Quantitative analysis of patient A-lines reveals distinct patterns in relative attenuation coefficients in young and old patients. (A) Example image of a 2-year-old true vocal fold edge. (B) Example image of a 16-year-old true vocal fold edge. Representative regions of interest with a height of 2000 μm (white boxes) are shown. The endosheath (black arrow) and epithelium (white arrow) are indicated. (C) Young and old patient A-lines. Demarcation of zones 1, 2, and 3 are shown in both populations. (D) Mean relative attenuation coefficients for zones 1, 2, and 3 for each patient group. Zone 1 was distinct relative to zones 2 and 3 for each group. Zone 2 was distinct from zone 3 in older patients but not in younger patients. (E) Placing the region of interest series 600 μm inferior to the vocal fold edge (young: 600) did not significantly change relative attenuation coefficients when compared to analysis by placing the region of interest series 300 μm inferior to the vocal fold edge (young: 300). The relative attenuation coefficients between groups young: 300 and young: 600 were indistinct and had the exact same pattern of statistical significance when compared to older patients (old: 600). *$P < .05$.

Laryngoscope 126: June 2016 Garcia et al.: Studying Vocal Fold Maturation With OCT

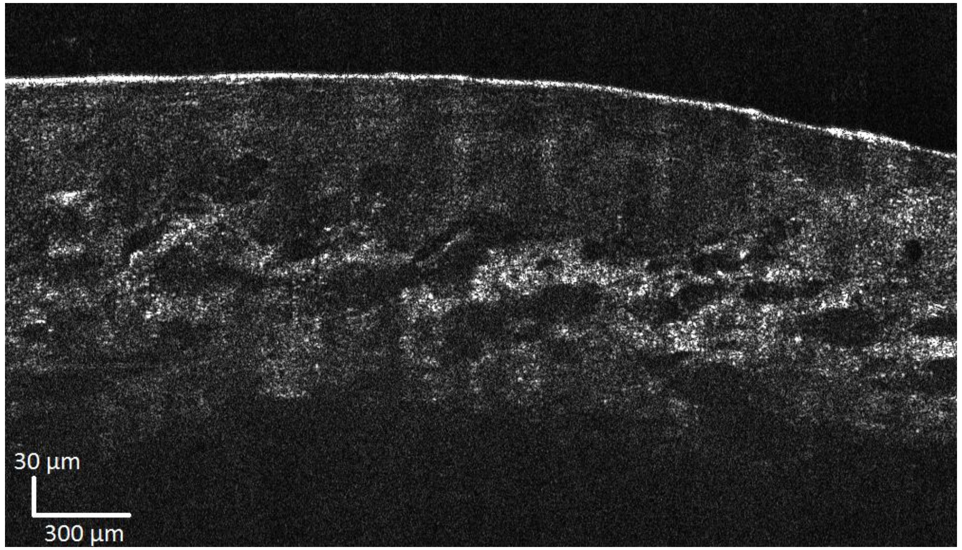
E221

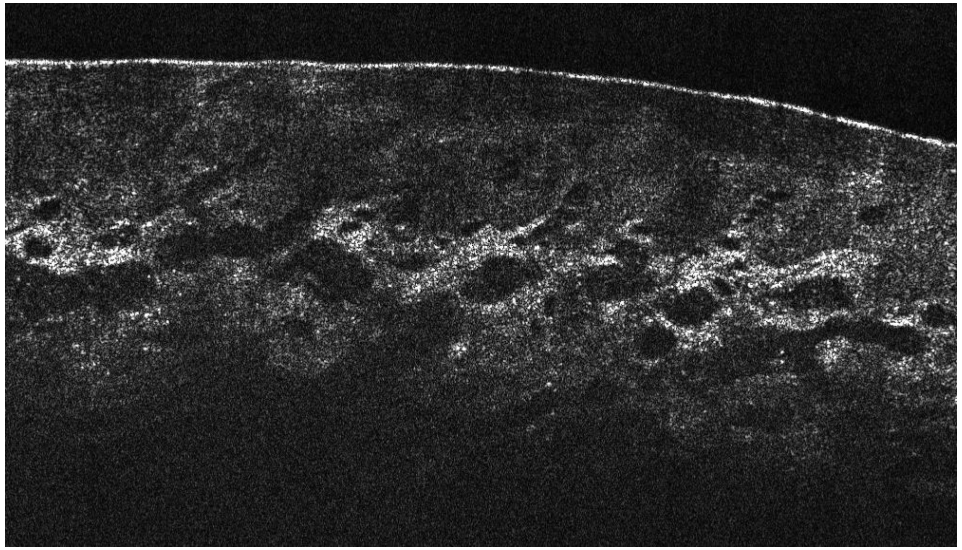
Future

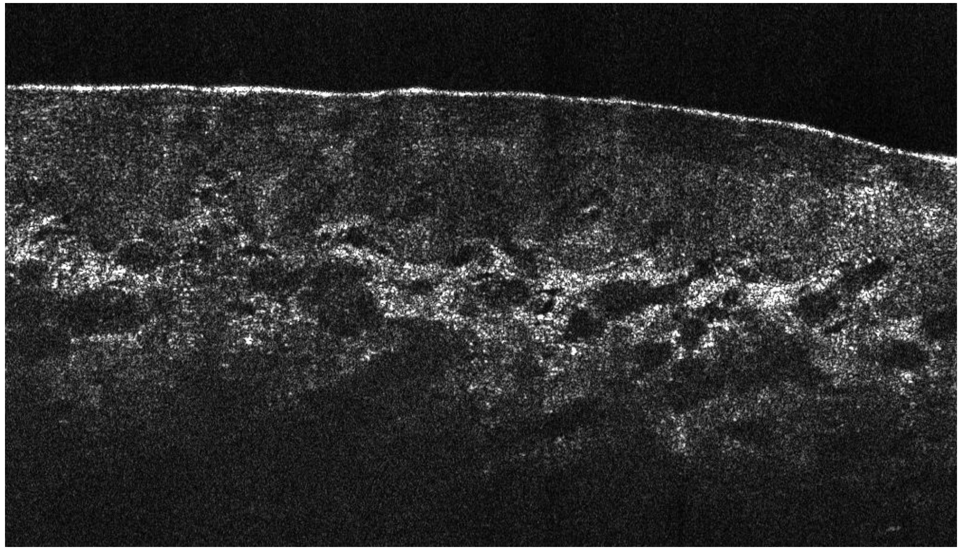
ULTRAHIGH RESOLUTION OPTICAL COHERENCE TOMOGRAPHY FOR DETECTING TISSUE ABNORMALITIES OF THE ORAL AND LARYNGEAL MUCOSA: A PRELIMINARY STUDY.

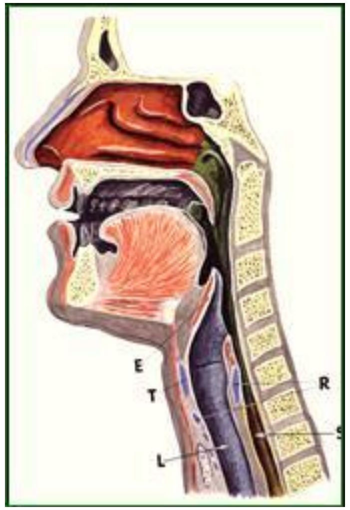
Niels Møller Israelsen, Mikkel Jensen, Anders Overgård Jønsson, Mette Pedersen.

Maveba 2019 in print









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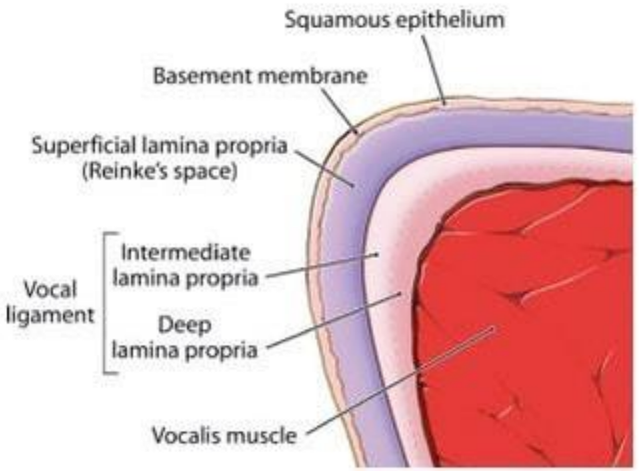
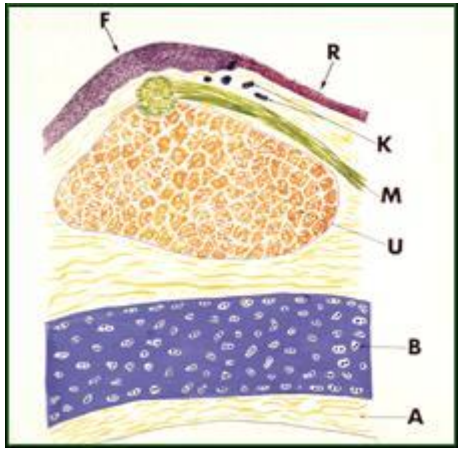
anatomionline.dk



Source: http://www.clevelandvoiceandsleep.com



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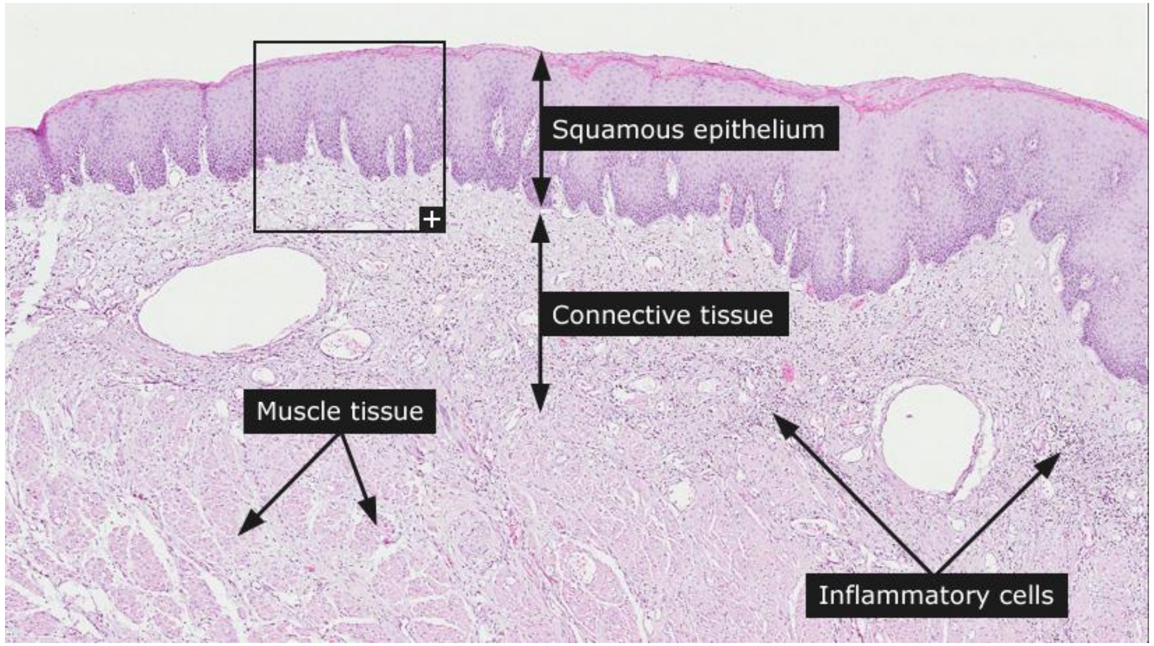
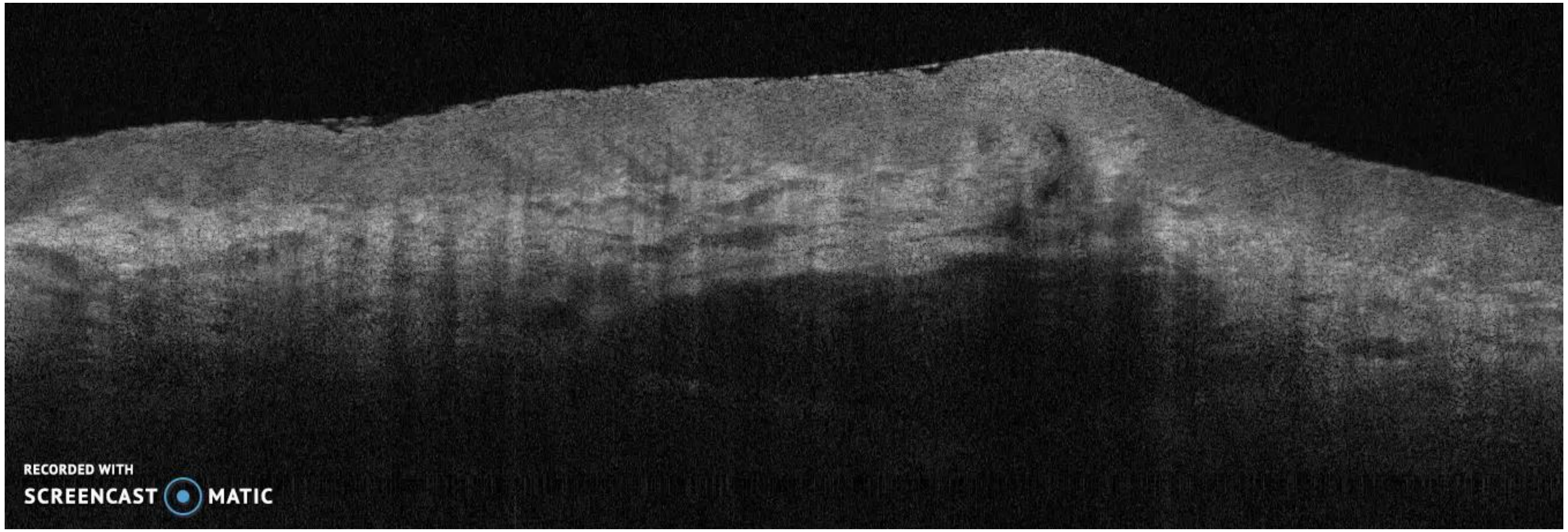
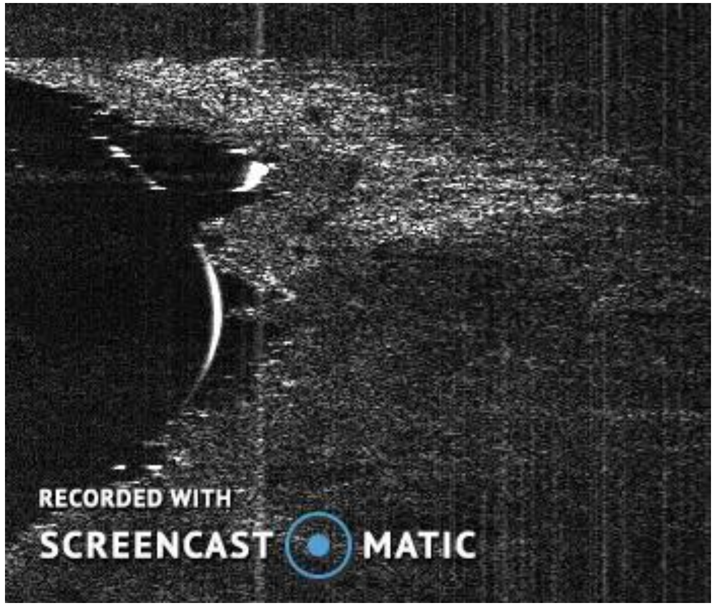
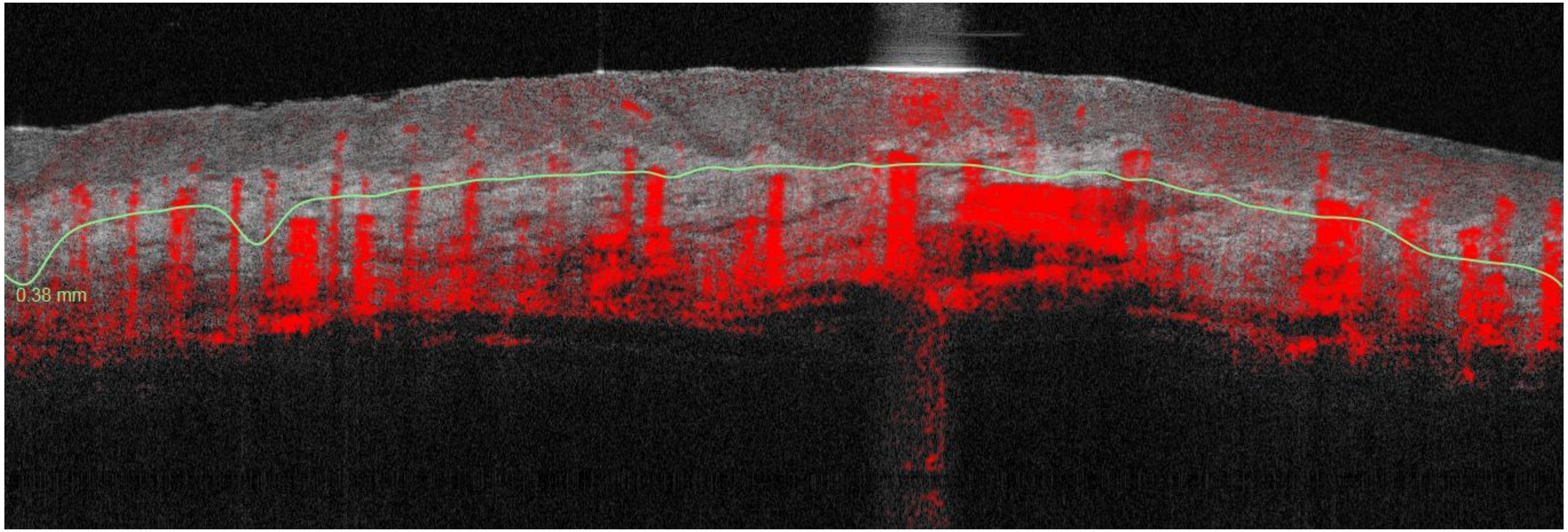


Biopsy of mucosal tissue in the mouth

Vivosight billeder 6x6 mm







To finish we present 2 abstracts to show you that we are not the only ones focusing on improving tissue diagnostics in the larynx.

14 March 2018

WIDE-FIELD AND LONG-RANGING-DEPTH OPTICAL COHERENCE TOMOGRAPHY MICROANGIOGRAPHY OF HUMAN ORAL MUCOSA

(Conference Presentation)

Wei Wei; Woo June Choi; Shaojie Men; Shaozhen Song; Ruikang K. Wang
Univ. of Washington (United States)

Novel use of long ranging swept source optical coherence tomography (SS-OCT) system with unprecedented **imaging field of view of 1600 mm2** for anatomic and microvascular imaging of human oral mucosa tissue **in vivo**. This system is further applied to identify and analyze oral mucosa lesions in situ without a need for invasive biopsy. Qualitative assessment of the structure characteristics (i.e. collagen fibrosis, volume of salivary glands, and tissue scattering) during wound healing delineates the anatomical lesion development accompanied with tissue inflammation. **Quantitative assessment of the vasculature network** (i.e. capillary loop density and vessel morphological orientations) reveals pathological and nutritional underpinnings of microcirculation for oral lesion recovery. Specifically, the **progression of oral capillary angiogenesis**, indicated by elevations in capillary loop density, occurs **within 12 hours of disease onset and peaks at day 7 thereafter**, which provide invaluable information for the time course of therapeutic treatment. Our demonstration shows potential movement of oral cavity OCT microangiography toward **clinical translations**.

4 March 2019

OPTICAL BIOPSY OF VOCAL FOLDS DURING PHONATION USING PARALLEL OCT (Conference Presentation)

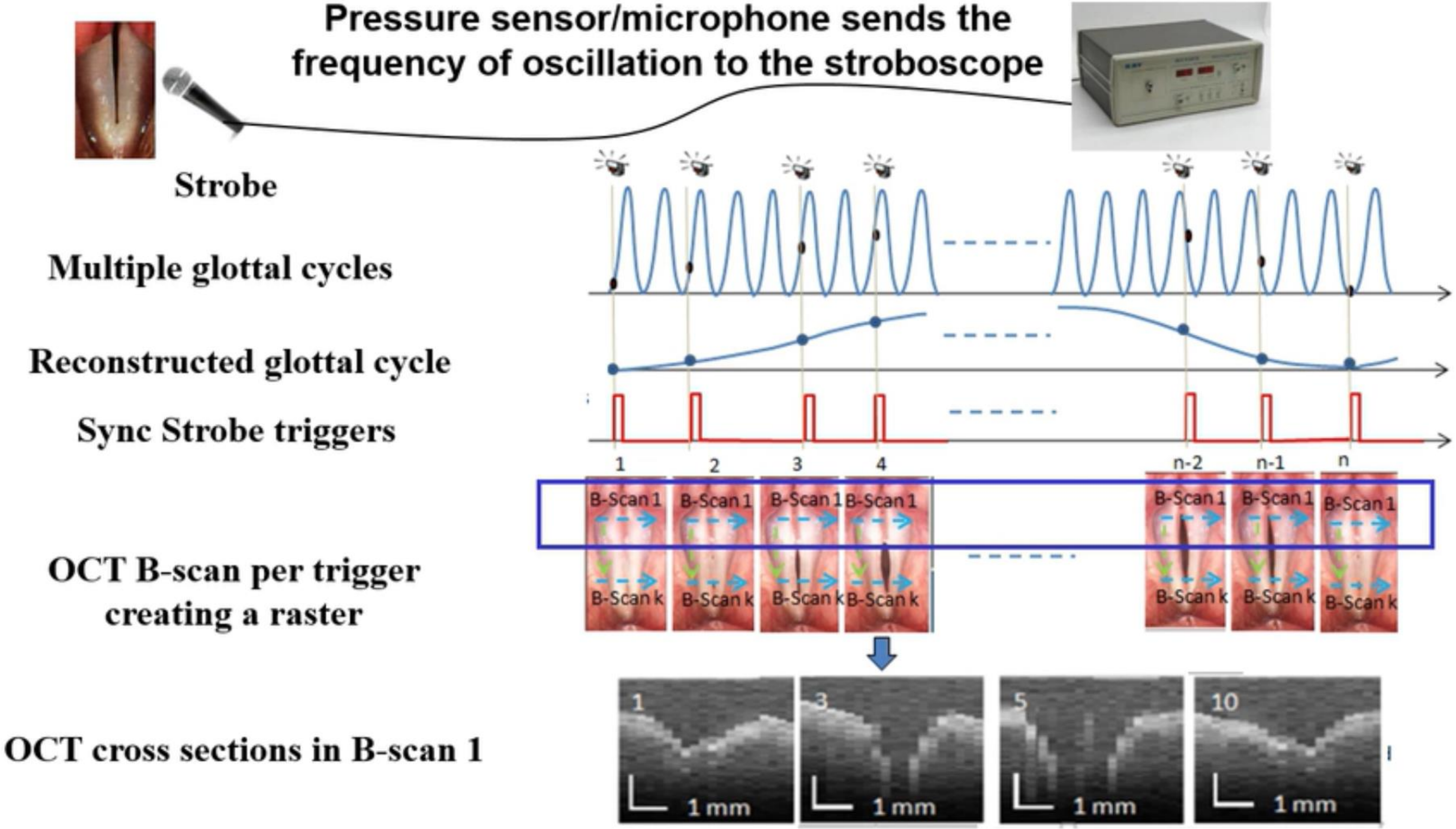
Gopi N. Maguluri; Daryush D. Mehta; James B. Kobler; Jesung Park; Nicusor V. Iftimia
Author Affiliations - **Gopi N. Maguluri,[1] Daryush D. Mehta,[2] James B. Kobler,[2] Jesung Park,[1] Nicusor V. Iftimia[1]**

[1]Physical Sciences Inc. (United States)
[2]Ctr. for Laryngeal and Voice Rehabilitation, Massachusetts General Hospital (United States)

There is a constant need of an endoscopic imaging tool in voice clinics that can directly capture the three-dimensional (3D) surface motion of the vocal folds in real time as patients phonate. To address the need, we will present a Parallel OCT/Video Stroboscopy imager that will combine parallel swept source OCT technique with Video Stroboscopy to provide a real time display of the vocal folds in all three axial dimensions during phonation. The results will yield cross sections (B-Scans) with ~16 co-linear sampling locations spread over ~5mm on a **phonating ex-vivo calf larynx** showing fluid periodic cyclic motion of the vocal folds (~A-scan rate) in real time enabled by Parallel OCT approach. We will also capture **Video Stroboscopy images in sync with Parallel OCT B-scans** validating the real time cross sectional probing of Parallel OCT/Video Stroboscopy imager.

OCT-VS Synchronization

Physical Sciences Inc.



Each reconstructed glottal cycle will produce ~10 phases at one cross section
Move B-sc ent cycles

to the strobe.

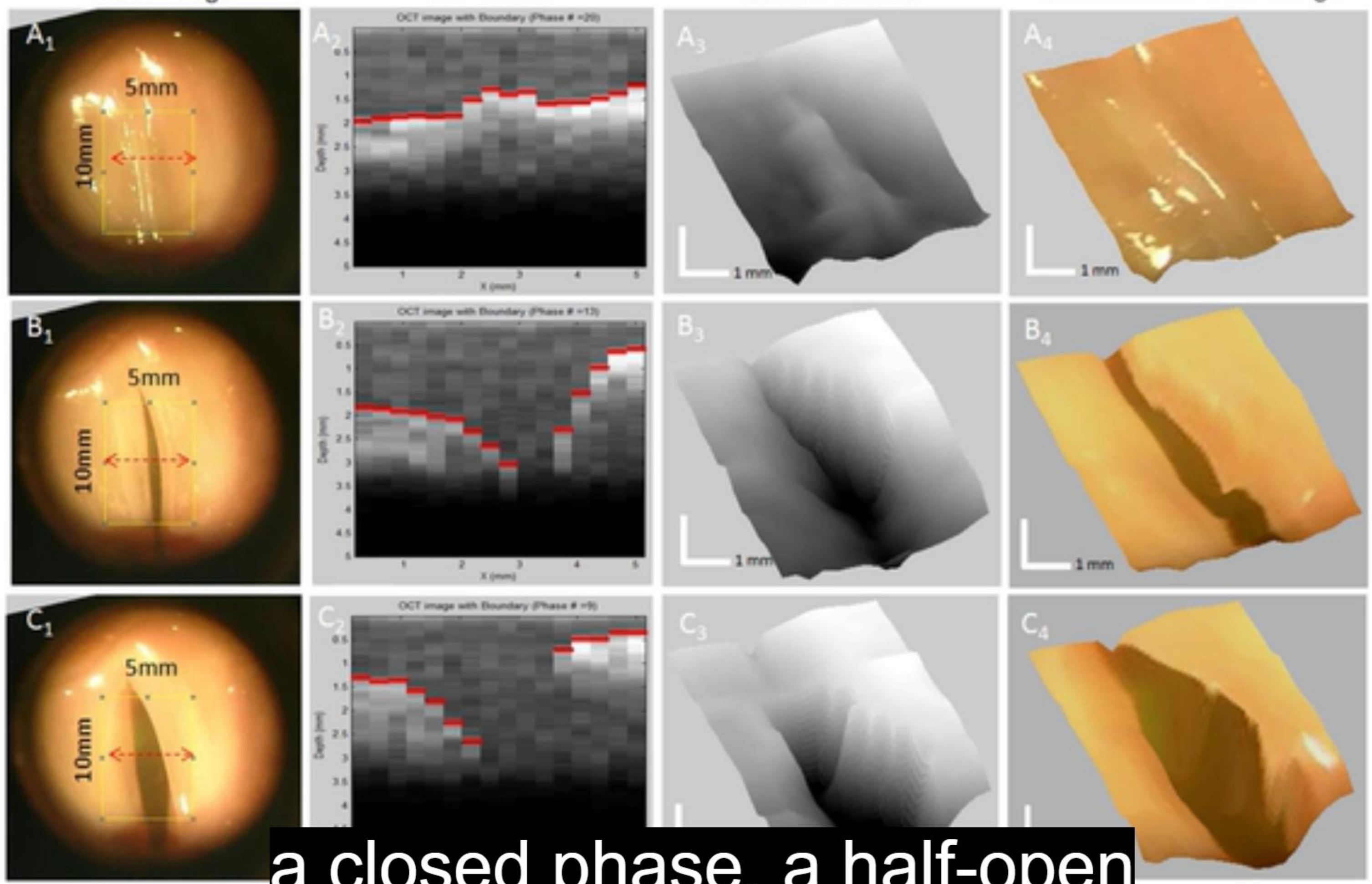
Instrument

Post processing - 3D Display

Physical Sciences Inc.

MGH 1811

Video Image | OCT Frame | OCT 3D Surface | Reconstructed Video Image



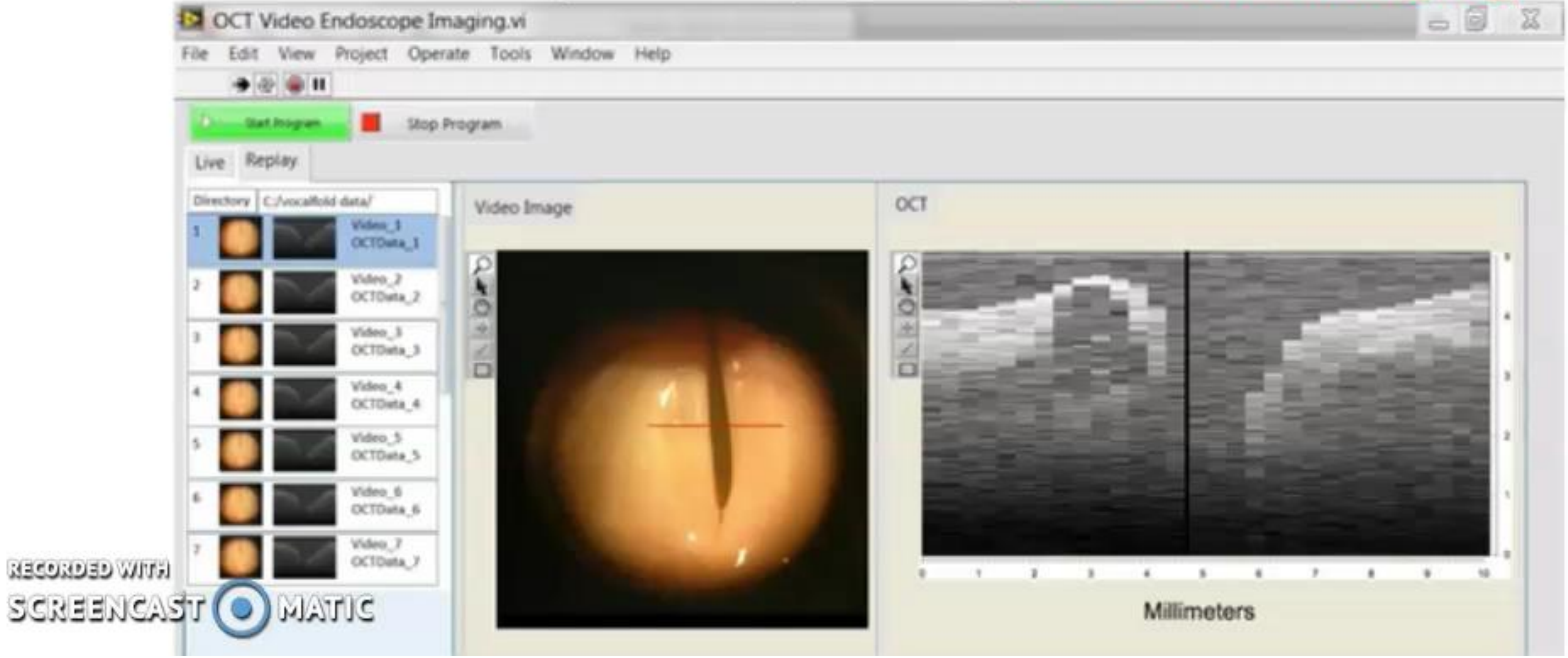
a closed phase, a half-open
phase, and a fully-open phase.

Video ... erimposed ... T 3D

Pilot Data

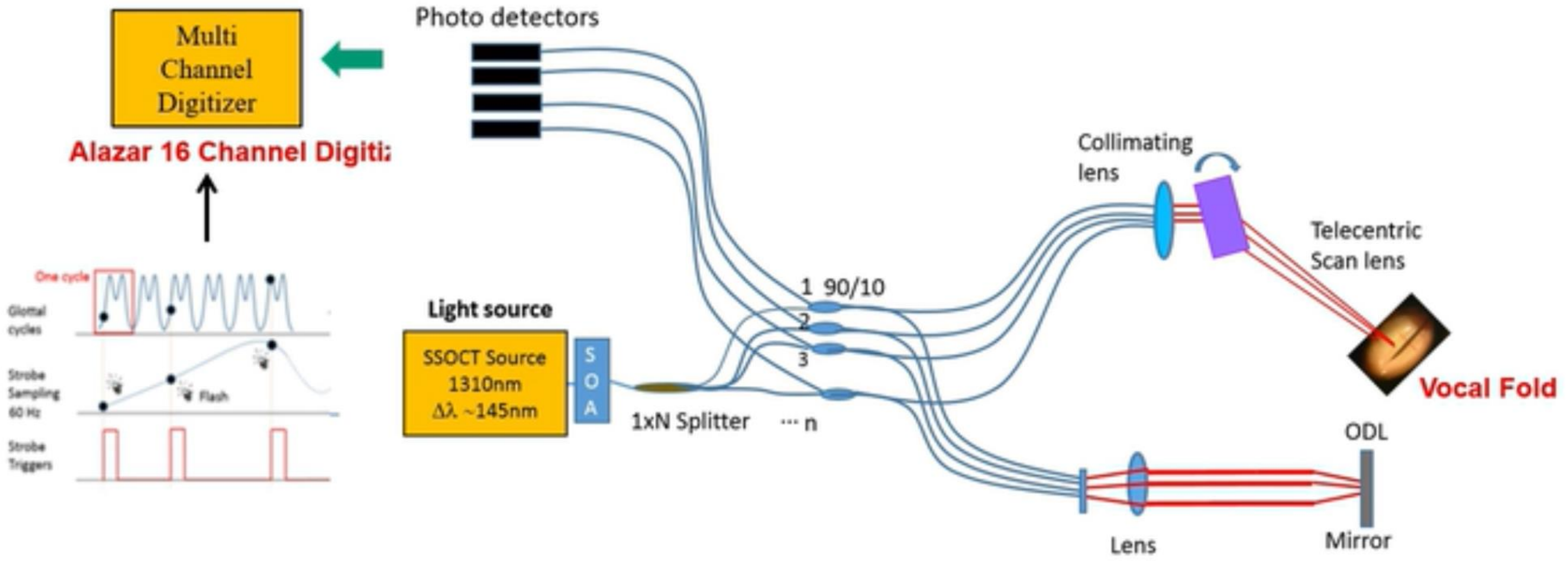
Pilot Data OCT+VS (Dynamic)

Restylane injected under the surface can be clearly seen as circular zone (~1.25mm) in OCT (Subsurface imaging)



New approach: Parallel OCT(pOCT)/VS Imager

- Address with parallel OCT approach
- No galvanometer for B-scan
- Instead, 16 beamlets spanning ~5-10mm; each an individual OCT system



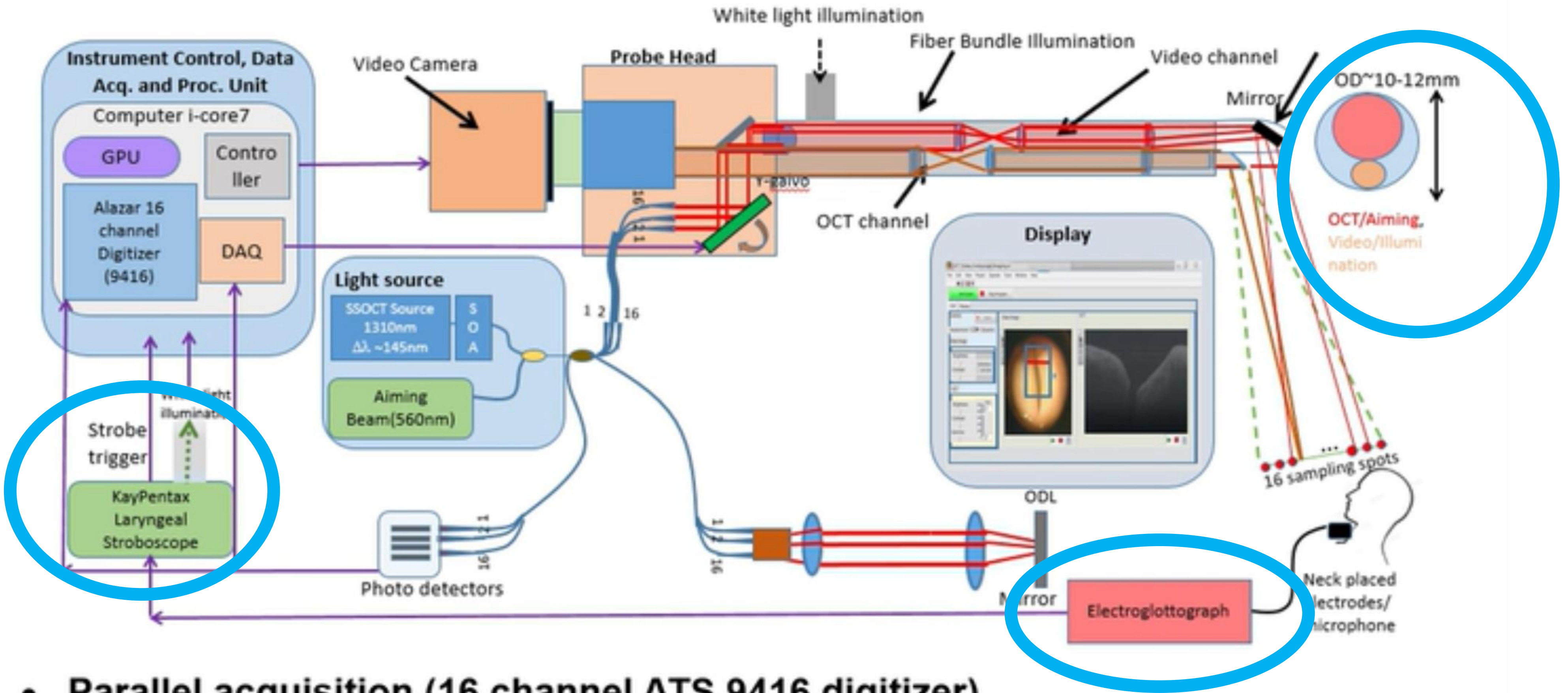
- Source: Santec 20 kHz; (lets us use low cost low speed OCT systems)
- SOA- Reduces the bandwidth but will provide the power needed ~50mW
- 16 channel Acquisition (Alazar at 100MS/sec)

Probe head

Proposed pOCT Probe Head

Physical Sciences Inc.

OD ~10mm



- **Parallel acquisition (16 channel ATS 9416 digitizer)**
- Clinically adaptable (OD 10-12mm); produces fluid mucosal wave motion
- All beam paths, (OCT, Video, white light illumination and aiming beam within OD
- Synchronous with VS (video);

pOCT Hardware

Disadvantage: No morphological mode (No dense sampling but it is not vital)

Conclusions

- **Designed and developed Gen-1 OCT-VS Imaging instrument**
- **Demonstrated synchronous OCT/VS imaging on ex-vivo vocal folds.**
  - 3D imaging with spatial co-registration and temporal synchronization is demonstrated
  - Dynamic cross-sectional imaging is demonstrated during phonation.

- **Designed next generation probe head using parallel OCT technique to achieve clinical viability**
  - OD ~10-12mm
  - Capability to achieve cross sectional (B-scan) imaging at up to A-scan rate

- **By next year, hope to demonstrate in-vivo imaging**