Endoscopic Probe for Airway Imaging using OCT

Subject: Optics and Photonics
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There are strong indications of a relation between asthma and the mass of airway smooth muscle (ASM). However, no present imaging modality is capable of quantifying ASM. If it would be possible to show that ASM is the key driver in asthma, new therapies can be developed. As a first step towards a clinical tool that could be used in vivo on humans, a high-resolution endoscopic probe for airway imaging in small animals using Optical Coherence Tomography (OCT) has been built.

Background

The primary structural abnormality identified in subjects with asthma is that airways contain a thicker airway smooth muscle (ASM) layer. It is currently very difficult to relate patient symptoms to ASM since no present imaging modality is capable of quantifying ASM. If this technical limitation could be overcome, and data emerged demonstrating that ASM was the key driver in asthma morbidity and mortality, then new therapies can be developed.

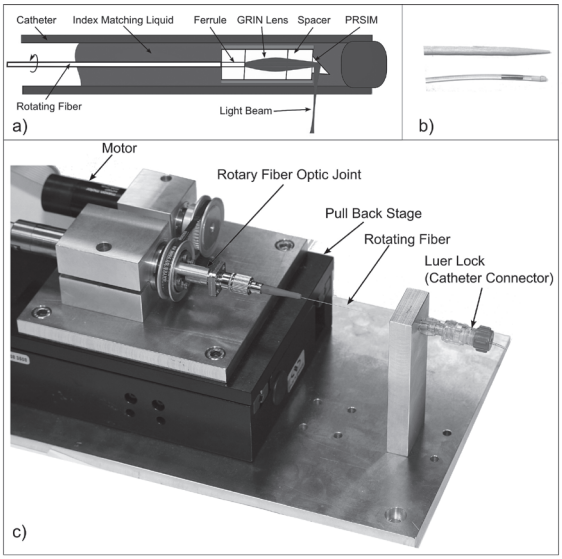
Design and realization

An endoscopic OCT probe with an outer diameter of 1.2 mm was designed and built with a lateral resolution of 9 µm. The associated control hardware and software was also developed, allowing both rotation and pullback of the endoscopic probe to acquire a three dimensional volume of the sample. The rotary scan mechanics allow a maximum speed of 20 B-scans per second and 7200 A-scans per probe revolution. The endoscopic probe was interfaced with an 840 nm spectral-domain OCT system which had an axial resolution of 9.3 um in air (6.6 um in tissue).

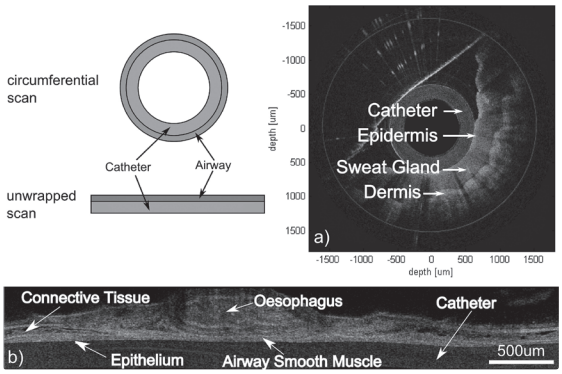
Results

The system developed within this project has demonstrated its ability to acquire high resolution images of airway structures, and delineate between these structures (e.g., cartilage, connective tissue, and glandular tissue). However, our imaging results indicate that the resolution of the current system is not high enough to reliably quantify the thickness of ASM in a wild-type mouse. Comparisons with histology showed the ASM layer to be very thin, often only 10–20 µm. Furthermore, the contrast between ASM and the surrounding tissue is not very strong in the OCT images. Further development is necessary, such as extension of the system to polarization sensitive OCT or optical coherence elastography.

Alexander Holzer



a) side-viewing endoscopic probe, b) 1.27mm catheter compared in size to a tooth pick, c) scan mechanism



a) finger tip pressed against the catheter (circumferential) c) mouse trachea (unwrapped)