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OCT is Clinically useful in Laryngology

Marie Laurent*

Department of Otorhinolaryngology and Cervicofacial Surgery, HEGP, AP-HP, 20, rue Leblanc, France

Optical coherence tomography (OCT) is an emerging imaging modality that combines a low-coherence light source and an interferometer to produce cross-sectional high-resolution images of living tissues. OCT works analogously to ultrasonography but instead of sound uses near-infrared light to discern variation in tissue optical properties. Clinical OCT devices have an axial resolution of approximately 10 µm and a maximum depth penetration of 2 to 3 mm, although 1 to 2 mm is more typical because most biologic tissues are turbid.This technology has been widely used in ophthalmology for examination of the retina, cornea, and macula and as a guide in cataract surgery. OCT has been evaluated in other specialties, including dermatology, cardiology, pulmonology, gastroenterology, urology, and neurology, although primarily using research OCT systems designed and constructed by specialists in photonic technologies at academic medical centres [1].

In the head, neck, and upper aero digestive tract, clinical OCT has focused on examination of the larynx, with one goal: to distinguish benign from micro invasive cancer that has violated the integrity of the basement membrane (BM). Some work has focused on using OCT to perform image-guided therapy of the larynx, although the results have been mixed. It has also been used coupled to a surgical microscope, allowing hands-free OCT simultaneously with microscopic visualization of the vocal cords. More recently, we pioneered the use of OCT to image both the neonatal and the pediatric airway with the aim of examining changes in the subglottis following prolonged intubation. OCT has also been used to image the middle ear and thyroid gland. The oral cavity has been studied comprehensively using OCT and is reviewed elsewhere. Outside of ophthalmology, most clinical OCT studies have involved the use of systems designed and built by research groups focused on enhancing the resolution, image acquisition rates, and functionality of this nascent imaging modality. Until recently, there has not been a commercially available turnkey OCT system for use in the head and neck, and most studies to date have used research devices designed and constructed in university optics laboratories. At University of California Irvine, we have had an active OCT research program at the Beckman Laser Institute and Medical Clinic for over 15 years, with over 7 years of clinical experience on OCT imaging in the head and neck in human subjects. Our investigations to date have used only OCT systems designed and constructed in our laboratories. The objective of this study was to present our experience with using the first commercially available OCT device designed to image the larynx among other applications and to compare its use with our previous experience in over 200 patients using research OCT systems [2].

OCT imaging was performed in 33 patients undergoing upper aero digestive tract endoscopy under general anesthesia, under the aegis of the Institutional Review Board at the University of California Irvine. Two subjects were imaged twice during two separate operations. Twenty-one patients (64%) were male and 12 patients (36%) were female. The average age was 53 years. Imaging generally required 3 to 5 minutes of additional surgical time [3].

OCT System:

A commercially available clinical imaging system was used to examine each patient. This portable time-

*Corresponding author: Laurent M, Department of Otorhinolaryngology and Cervicofacial Surgery, HEGP, AP-HP, 20, rue Leblanc, France, E-mail: Laurent @tonhsc.fr

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domain OCT system uses a low-coherence near-infrared light source to acquire real-time images of 200 × 200 pixels at a maximum frame rate of 0.7 Hz. The spatial depth resolution of the system is 10 to 20 µm, with a depth scanning range of 2.2 mm. In practice, owing to the turbidity of living tissues, scanning depth is only about 1.5 mm. The lateral resolution is 25 µm, with a lateral scanning range of 1.5 to 2.5 mm. In OCT systems, lateral resolution is diffraction limited, whereas axial resolution depends on the coherence length of the light sources. It uses a 2.7 mm diameter reusable flexible probe to obtain the images. To the user, the probe appears as a single, compact instrument; however, it encases a single-mode optical fibre, which is scanned back and forth within by a solenoid [4].

Intraoperative Imaging:

After exposing the larynx using a surgical laryngoscope with suspension, the probe was inserted through the laryngoscope using a modified suction handpiece to allow accurate placement of the probe tip on the area of interest. Under microscopic or rigid telescope guidance, the probe tip was placed in gentle or near-contact with the region of interest. OCT images were acquired from the normal laryngeal tissue, the site of the pathology, and in transition zones in the case of potential cancers. In most of the patients, still images of the lesion were acquired using conventional digital imaging, which also aided in providing a record of the probe position.

OCT has limited capabilities in imaging large and bulky laryngeal lesions because the BM cannot be consistently identified, making it difficult to evaluate BM infiltration and to distinguish between benign and malignant lesions. Thus, OCT has its greatest potential value in examining superficial and subtle lesions and disease processes. This device has limited utility for imaging bulky lesions but might be useful to evaluate surgical margins following the resection of a bulky lesion and as an adjunctive technology for use in transoral laser microsurgery. This system is an easy to use device, is portable, requires a single operator, and takes approximately 3 to 5 minutes to set up. Although the image quality is limited relative to previously described research devices, laryngeal microstructures, such as the BM, LP, epithelium, glands, and capillaries, can be identified, still making this device valuable for select applications. OCT has potential use as a complementary tool for diagnosing various laryngeal pathologies. It can be a great asset in the operating room in guiding surgical biopsies, decreasing the necessity of removing broader surgical margins, and intraoperative decision making [5].

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