Early detection and management of potentially malignant oral lesions can significantly reduce progression of these lesions into invasive cancer, and would thus reduce morbidity and fatality rate. Cancerous and potentially malignant lesions show dysplastic feature which is mostly detected by biopsy. However, biopsy has certain constraints like (i) biopsy can cause delay in the result, (ii) experienced pathologist must expound the biopsy sample (iii) sometimes can cause spread of cancer cells, (iv) cannot be done repeatedly. Therefore, in potentially malignant lesions and cancer optical coherence tomography (OCT) is utilized to detect early dysplastic changes. Therefore, we are presenting a review on the applications of OCT in oral mucosal lesions.

Keywords: Early diagnosis, Interferometry, Optical coherence tomography

INTRODUCTION

Oral cancer is predominantly preceded by white or red lesions that are visible to the unaided eye, and often present for a considerable period of time prior to their transformation. The current approach is consummately predicated on inspection, vital staining, tissue fluorescence, and biopsy. Histopathologic analysis of biopsy samples is the current “gold standard” for detecting cancer of the epithelial tissue.1 Biopsy samples are abstracted from the patient afore being fine-tuned, stained, and examined by a pathologist for abnormalities in the morphology. Albeit this procedure is the standard practice of diagnosis, several drawbacks are also associated with this, like (i) Biopsy can cause delay in the result, (ii) Biopsy sample must be examined only by experienced pathologist, (iii) sometimes can cause spread of cancer cells, (iv) cannot repeatedly be done, (v) biopsy cannot be done in vascular malformations.2

It is pellucid that ameliorated screening and diagnostic technologies are needed to surmount these inhibitions. In recent years, a substantial amount of research has fixated on developing optical predicated, detection techniques because such methods hold great promise to surmount the constraints of traditional biopsy listed above. These include chemiluminescence, spectroscopy, autofluorescence, in-vivo microscopy, photosensitizers, and optical coherence tomography. These optical diagnostics have certain advantages over the other diagnostic methods like (i) non-invasiveness, (ii) expeditious result, (iii) repeatability, (iv) authentic time information, (v) high-resolution surface and subsurface images, (vi) patient-friendly.3

OCT was first introduced as an imaging technique in 1991 by Huang et al.3 Optical coherence tomography (OCT) gives an incipient high-resolution image that sanctions minimally invasive imaging of near surface abnormalities in involute tissues. It has been compared to ultrasound (US) imaging conceptually. Both US and OCT provide real-time structural imaging, OCT is predicated on low coherence interferometry, utilizing broadband light to provide cross-sectional (CS), high resolution sub-surfaces tissues images, whereas US, which utilizes sound waves.2 4

PRINCIPLE

Optical coherence tomography and US imaging has most often been compared. OCT and US imaging employ backscattered signals reflected from different layers in the tissue to reconstruct structural images, with the US imaging quantifying sound waves rather than light. The resulting
optical coherence tomography image is a 2D representation of the optical reflection in a tissue sample.\textsuperscript{3,4}

Interferometry is the main principle of OCT. It is an evolving imaging modality that cumulates interferometry with low-coherence light to engender high-resolution tissue imaging. CS \textit{in-vivo} images were obtained utilizing an OCT contrivance consisting of a Michelson interferometer, light source (1.3 μm broadband), and a handheld fiber optic imaging probe. Image pixel has reached the resolution of 10 μm. Broadband laser light waves are emitted from a source (Ws) and directed toward a beam splitter. One wave from the beam splitter is sent to the tissue sample (Wt) and the other toward a reference mirror (Wr). After the two beams reflect off the reference mirror and tissue sample surfaces at varying depths, they are directed toward the beam splitter, where they merge and together are directed to the photo detector (Wp), which will further analyze the beams (Figure 1). The analyzing interference of the recombined light waves engenders the image. CS images of tissues are constructed in authentic time, at near histologic resolution of 10 mm. The 10 mm resolution of OCT displays depth, thickness, peripheral margins, and histopathological appearances of the tissues \textit{in-vivo}. Thus, OCT ameliorates on subsisting clinical capabilities, particularly for the identification of biopsy sites for monitoring of lesions, and for screening of a high-risk population. With 1-3 mm of tissue perforation depth, the imaging range of OCT diagnostics is opportune for the oral mucosa. The normal human oral mucosa is very delicate, ranging from 0.2 mm to 1 mm in thickness. Different scanning procedures in OCT imaging are axial scans withal called as A-scan, longitudinal scan or B-scan, En-face scans or T-scans and transverse slice scans withal called as C-scan.\textsuperscript{5-7}

There are different types of OCT, which are; time domain OCT which uses an interference pattern is obtained by moving the reference mirror in a linear fashion, spectral domain/fourier domain which uses spectrometer to measure the spectral density, and time encoded domain/swept source domain where frequency-swept laser or a tunable laser is used to obtain the spectrogram.\textsuperscript{5}

\textbf{Uses in the Soft Tissue Pathologies}

\textbf{Malignant and potentially malignant condition}

OCT can detect early transmutations in malignant and premalignant changes like loss of epithelial stratification, hyperkeratosis, epithelial down growth, disruption of the basement membrane.

Wilder-Smith \textit{et al}., 2009 have done a visually impaired study involving 50 patients evaluated the efficacy of OCT in detecting oral dysplasia and malignancy in cases with suspicious lesions including leukoplakia or erythroplakia of the oral cavity. Epithelial thickening, epithelial down-magnification, and loss of epithelial stratification, all of which have been revealed in OCT images of dysplastic lesions.\textsuperscript{5} Wilder-Smith \textit{et al} in 2009 reported, sensitivity and specificity of 0.931 and 0.931, respectively, in detecting carcinoma \textit{in-situ} or squamous cell carcinoma (SCC) versus non-cancer; sensitivity and specificity of 0.931 and 0.973, respectively, in the detection of SCC versus all other pathologies.\textsuperscript{4}

In another study of 97 patients utilizing OCT imaging to detect neoplasia in the oral cavity by Tsai \textit{et al} in 2009, their results revealed that the an important criteria for high-grade dysplasia/carcinoma \textit{in-situ} was the lack of a layered structural pattern. Diagnosis predicated by this method for dysplastic/malignant versus benign/reactive conditions achieved a sensitivity and specificity of 83% and 98%, respectively, and by 0.76 as an inter-observer accident value. Their study concluded that OCT, had high sensitivity and specificity along with a good inter-observer acquiescent, is a promising imaging modality for non-invasive evaluation of tissue sites, suspected with high-grade dysplasia or/and cancer.\textsuperscript{9} Lee \textit{et al} in 2009 had diagnosed the OSMF with OCT. Compared with the conventional method of quantifying maximum mouth opening, the utilization of the proposed OCT scanning results can be a more accurate technique for OSF diagnosis.\textsuperscript{9}

\textbf{Cancer therapy-induced mucositis}

OCT has proven its utility in the detection of transmutations in cancer therapy-induced mucositis. Oropharyngeal mucositis occurs in 30-75% of chemotherapy patients, 75% of patients receiving a hematopoietic cell transplant, and basically all the patients experiencing head and neck radiation therapy in doses of >5000 cGy. It is very arduous to prognosticate the exact onset and rigor of mucositis which can cause arduousness in treatment. OCT can detect early vicissitudes in mucositis which will ameliorate the aversion and treatment effect.\textsuperscript{10,11}

\begin{figure}[h]
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\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{Picture showing physics behind optical coherence tomography}
\end{figure}
Shivhare, et al.: Optical Coherence Tomography

Kawakami–Wrong et al. 2007 had done study in which five patients receiving neoadjuvant chemotherapy for primary breast cancer, oral mucositis, and OCT was used to clinically assessed and imaged. Imaging was scored utilizing a novel imaging-predicated scoring system. Oral mucositis assessment scale was used as the gold standard for conventional clinical assessment. Patients were evaluated on 0, 2, 4, 7, and 11 days after beginning the chemotherapy. One blinded investigator viewed the OCT images. The findings in the study were:

- Transmutation in epithelial thickness and subepithelial tissue integrity (beginning on 2nd day), loss of continuity of surface keratinized layer (beginning on 4th day), and loss of epithelial integrity (beginning on 4th day). Higher scores were obtained for imaging data compared to clinical scores earlier in treatment, suggesting the higher sensitivity of imaging-predicated diagnostic scoring to early mucositis change than the clinical scoring system. Imaging and clinical scores converged, after establishing the mucositis.
- OCT identified oral changes induced by chemotherapy prior to their clinical manifestation, and the proposed scoring system for oral mucositis was validated for the semi quantification of mucositis change.

Muanza et al. in 2005 performed a study in murine radiation-induced mucositis models. The study concluded that OCT can be subsidiary for both qualitative and quantitative assessments of acute mucosal damages. There were paramount vicissitudes in the mucosa detected by the OCT images afore visible macroscopic manifestations, like ulcers became ostensible.

**Oral vascular malformation**

Ozawa et al. 2009 detected the two cases of vascular malformation, one with a capillary-venous malformation of the lower lip whereas the other with a reddish mass on the buccal mucosa. In these cases, OCT images correlated well with histological structures, exhibiting well demarcated capillary vessel lumina and endothelial lining. Cognizance of the size, area, and the border of the vascular lesions can be subsidiary for the diagnosis and cull of surgical treatment, particularly for vascular anomalies, and hemangiomas in the oromaxillofacial region.

**Mucocutaneous lesions**

There is a certain skin disorder which is detected by OCT. However, it requires a specific attention for skin disorders whose incidence is additionally higher in the oral cavity, like lichen planus, pemphigus, pemphigoid, and so on.

Forsea et al. had done studies of three patients with psoriasis and came to conclusion that OCT showed typical thickening of the epidermis, with epidermal protrusion into the dermis, vigorous hyperkeratosis as a more tenebrous superficial band.

Forsea et al. had detected sarcoidosis with OCT. There were hypo-dense confluent rounded structures in the dermis corresponding on the histopathology exam to granulomatous infiltrates.

**ADVANTAGES OF OCT**

(i) Non-invasive, (ii) high-resolution, (iii) repeatability, (iv) reduces the chances of further spread of infection, (v) capability to distinguish different layers like epithelial and sub epithelial layers, (vi) patient friendliness, (vii) live subsurface images at near-microscopic resolution, (viii) instantaneous direct imaging of tissue morphology, (ix) preparation of the sample or subject is not required, (x) no contact is made with the patient, (ix) No use of ionizing radiation.

**CONCLUSION**

OCT has already gained much attention in the field of ophthalmology and cancers of other components of the body, but now it is required to give consequentiality to those in the field of oral diseases due to its noninvasive nature and other advantages which will be propitious to the dentist and the patients. OCT can provide resolution images of tissue in-situ without the need for surgical biopsy.

The high resolution in authentic time, the lack of incursion, and its ease of handling provide safe designates of imaging oral structures at a caliber that is otherwise only obtainable by histological examination of a biopsy specimen. Moreover, the emerging capability of amalgamating in-vivo OCT with in-vivo Doppler techniques for imaging and quantifying perfusion is very captivating.

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