Review Article

Optical Coherence Tomography for Oral Mucosal Lesions – A Review Article

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Abstract: Optical coherence tomography (OCT) is used to produce the cross sectional images of tissues. It is a non-invasive technique. It was first introduced by Huang and co-workers in 1991. It can be used for imaging and diagnosing epithelial and subepithelial dysplastic changes within the oral mucosal tissues and in the detection of early oral cancer. Optical coherence tomography produces higher resolution for imaging the epithelium and lamina propria within the normal and dysplastic oral mucosal tissues. Optical coherence tomography technique utilizes near infrared light which allows it to penetrate into the scattering medium and produces submicrometer resolution. OCT can also be used for imaging the early dental caries. This article focuses on the importance of optical coherence tomography which can be used as a diagnostic tool for imaging the oral mucosal tissues.
Keywords: Dento-enamel junction, Interferometry, Tomography, Lamina propria.

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Introduction

About 200,000 deaths occur annually in the world due to oral cancer. In developing countries the incidence of oral cancers is more when compared to the developed countries especially in South-Central Asia and Central and Eastern Europe.[1] In India approximately about 46000 deaths occurs annually due to the oral cancer. Oral cancer is one of the highest incidences in India constituting around 12% of all cancers in men and 8% of all cancers among women. In India the use of gutka, a smokeless tobacco product increases the risk of developing premalignant diseases such as leukoplakia and oral submucous fibrosis especially in younger patients. The use of alcohol, smokeless tobacco products and betel quid chewing increases the risk factors for oral cancer. India is the second largest producer of tobacco and approximately about 274.9 million population of the world consumes tobacco according to the recent data (Global Adult Tobacco Survey- GATS, 2010). As per this report more than one third (35%) of adults in India use tobacco in some form or the other, 163.7 million are users of only smokeless tobacco, 68.9 million only smokers and 42.3 million users of both smoking and smokeless tobacco.[2] The most

common type of oral carcinoma is the squamous cell carcinoma which accounts for about nine or every ten oral malignancies. Oral premalignant lesions which develop into oral cancers are leukoplakia, erythroplakia, erythroleukoplakia, dysplasia and carcinoma insitu. The malignant transformation rates of oral premalignant lesions are reported to be about 1-7% for homogenous, thick leukoplakia, 4-15% for erythroleukoplakia, 4-11% for moderate dysplasia and 20-35% for severe dysplasia.[3] Because of higher malignant transformation rates of oral premalignant lesions there is a need for early detection and diagnosing of oral mucosal dysplastic changes.

OCT Principle and System:

Optical coherence tomography is an emerging non-invasive optical technique which produces imaging of near surface abnormalities in complex tissues. Tomographic techniques can produce non-invasive diagnostic images of biological tissues. There are two fundamental optical tomography techniques - diffuse optical tomography (DOT) and optical diffraction tomography (ODT). Optical coherence tomography is based on ODT. Diffuse light for imaging the biological tissues. OCT was first utilized to image the transparent tissues of the eye. produces tomographic images. OCT uses ballistic and near-ballistic photons.[4]

Optical Recently OCT is also used for imaging non-transparent tissues like the skin, oral cavity and in various endoscopic applications such as for oesophagus, colon and ovarian imaging.[5] optical tomography (DOT) uses diffusely propagating photons. Optical diffraction tomography uses single scattered light and coherence tomography uses near infrared OCT is considered as an analogue to ultrasound as both are used to image biological tissue but OCT utilizes light instead of sound waves which are utilized in ultrasound. Optical coherence tomography is an optical technique which utilizes low coherence interferometry of broadband light to produce high resolution and cross-sectional images of the tissues.[6] It has a penetration depth of about 1-3mm within the tissues and can produce a resolution of better than 10-20µm. The OCT system is a fiber based system which uses a superluminescent diode producing a light source of 1.5 mw in power. The superluminescent diode operates at 950 nm with a bandwidth of 65nm. It consists of a scanning probe which has a stepper motor and is completely automated and controlled by a computer. The time required to finish a single scan in a transverse manner for 1mm depth is 0.2 seconds. The scanning probe is a L shaped probe or a line shaped probe (Figure 1) with linear motors in them.[7] The specialized shape of the probe makes its rays convenient to use the probe in any area of the oral mucosa.

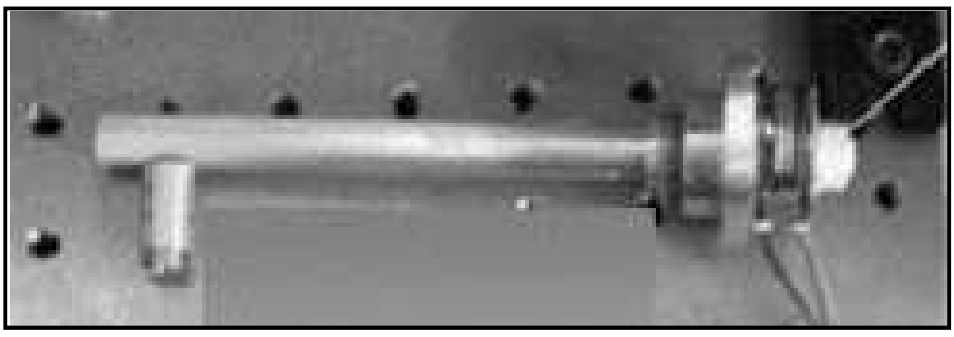

Figure 1: The L-shaped scanning probe. The length is around 10 cm and the width is around 2.7 cm.[7]

Discussion:

Optical coherence tomography is one of the new emerging technique for imaging oral mucosal tissues. It is a non-invasive technique which produces cross-sectional images of oral mucosal tissues at cellular and subcellular levels.[8] The diagnosis of oral premalignant diseases requires multiple biopsies to avoid misdiagnosis of the lesion and it also reduces the patient motivation to undergo further treatment. Optical coherence tomography is an optical technique which detects the most appropriate site for biopsy thus reducing multiple incisons. The tissues of the oral cavity are readily accessible for imaging with optical coherence tomography before the epithelium shows dysplastic changes in case of premalignant conditions.[9]

The advantages of OCT include cross-sectional images of the normal or abnormal tissues can be obtained without biopsy and no preparation of the sample or patient is required. As it is an optical technique and uses the light for imaging the tissues there is no exposure of the patient to ionizing radiation.[10]

Apart from imaging the normal and abnormal mucosal tissue changes OCT also images the microanatomical structures like tongue papillae, small blood vessels, salivary gland ducts, gingival tissues like sulcus, epithelium and connective tissue. Along with this it can be also used to image the hard tissue structures like enamel, dentin and dentoenamel junction, hence it helps in the early detection of carious lesions along with the degree of demineralization.[11]

In a study conducted by Zaid et al. 78 suspicious oral lesions which were biopsied surgically from 73 patients were imaged with optical coherence tomography. The images revealed intact basement membrane in benign and dysplastic cases and in case of invasive carcinoma there was partial or complete loss of basement membrane.[8]

In another study conducted by Wildes-Smith et al. in hamster cheek pouch model the invivo OCT imaging was done. The results revealed structural changes in the epithelium and subepithelial layers. The results also revealed that the stages of dysplasia can be differentiated as the resolution of OCT technology is increasing. They concluded that based on the resolution of OCT technology, the stages of dysplasia can be detected at the time of therapy.[10]

The first application of optical coherence tomography is applied in ophthalmology. In this field OCT is used as a routine diagnostic purpose. It is used for imaging the anterior and posterior part of the eye. It is used for imaging cornea, iris and intraretinal subcellular structures such as ganglion cell layer and photoreceptor layer. Endoscopic optical coherence tomography can be used for imaging the mucosal and submucosal changes in gastrointestinal organs such as oesophagus, stomach, duodenum and colon. It is used to image the structures such as glands, blood vessles, villi and crypts. Bouma et al. conducted an endoscopic OCT in 32 patients and concluded that the layers of oesophagus was clearly obtained and differentiation between Barrett's oesophagus, normal oesophagus and oesophageal adenocarcinoma could be made.[12]

Optical coherence tomography can also be used for imaging the layers of skin. This technology can be performed in dermatological conditions such as hemangiomas, melanomas, psoriasis, dermatitis, bullous skin diseases and skin cancers such as actinic keratosis, basal cell carcinoma and cutaneous malignant melanoma.[13]The penetration depth of optical coherence tomography is about 3 mm. Because of its limited penetration depth this technology cannot be used for imaging deeper tissue layers. Normal oral mucosal

tissues can be differentiated from abnormal/pathological tissues through OCT technology based on changes such as epithelial thickening, disorganized keratin layer in the epithelial and subepithelial structures. However adequate information regarding the cellular and subcellular changes such as nuclear size and shape, nuclear-cytoplasmic ratio and nuclear stratification is not described by this technique which adds upto be its major limitations.[8] In one study consisting of 50 patients with oral leukoplakia or erythroplakia the OCT technology was used which showed the epithelial thickening, loss of epithelial stratification and epithelial downgrowth but this information is not enough to grade the oral premalignant disorders.[14] Several studies have been performed to scrutinize the use of OCT for diagnosing oral premalignant and malignant conditions however no studies have adhered to specific diagnostic criterias to conclude the diagnosis for oral premalignant conditions.

Conclusion

Optical coherence tomography is an evolving imaging technology and a non invasive imaging technique for oral structures. It can be used for the diagnosis of oral premalignant and malignant changes in the oral mucosa. Because of its higher resolution and penetration depth it can be used for imaging the normal and abnormal changes in the oral mucosa but the sensitivity and specificity regarding the diagnostic value of optical coherence tomography are lacking. As it is a new emerging technology in dentistry several studies may be required to provide information regarding the use of OCT as a routine diagnostic value. Further studies are on the way to improve the resolution of the system and the probe capabilities which shall provide valuable information on the physiology of benign mucosal diseases and the development of oral cancers.

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