Optical Coherence Tomography (OCT) - A Novel Diagnostic Procedure

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Abstract

This paper reviews the current knowledge on optical coherence tomography (OCT) a noninvasive imaging modality. Commonly used by ophthalmologists, this method can also be applied to in vivo and in vitro imaging of oral structures. OCT is a tomography imaging technology which produces high-resolution cross-sectional images of the internal architecture of materials and tissues. OCT can be used for histopathological imaging, evaluation of prosthetic restorations and microleakage at prosthetic interfaces, for imaging root canals and root dentin and the presence or absence of apical microleakage and to detect osteointegration of dental implant. Thus, OCT can be used in various fields of dentistry and can help the clinician to overcome problems of diagnosis and treatment.

Key words: Optical Coherence Tomography, Noninvasive Investigation, Dentistry.

Introduction

During last two decades, OCT has evolved into a powerful technique for imaging of transparent and translucent structures. It's a non-invasive tomographic technique for obtaining high-resolution images. It works on the principle of fibre optic Low-Coherence Interferometry (LCI). In optical coherence tomography, we can achieve very thin, i.e. micron scale cross sectional images. This permits high resolution, ranging and characterization of optoelectronic components. It was used for the first time to measure the eye length in the field of biomedical sciences.[1] The LCI has a very high potential to provide micron slices from the hard and soft tissues. This particular ability of the optical coherence tomography enables us to check the apical microleakage in root canal treatment, quality of various restorative materials, and quality of prosthesis can be assessed accurately. The carious lesions, temporo-mandibular joint disc, periodontal soft tissue can be studied with greater resolution.

Oral Mucosa

OCT imaging of oral mucosa, can give details of following of oral mucosal structures:

1. *Masticatory Mucosa* (gingival and hard palate mucosa)
2. *Lining Mucosa* (soft palate, labial and buccal mucosa, ventral surface of the tongue).
3. *Specialized Mucosa* (lips, dorsum of the tongue).

OCT images of highly keratinized epithelium (marginal gingival , vermillion border of the

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lip, dorsal surface of the tongue, hard palate) differs from images of parts where epithelium evidences low or no keratinisation in its normal state (labial mucosa, floor of the mouth and soft palate). Keratinization reduces the contrast and makes it difficult to distinguish the lamina propria and submucosa from epithelium. The connective tissue and blood vessels have different optical properties this enables the examination of blood vessels and glands that are situated in lamina propria and submucosa.[2]

Malignant Lesions of Oral Mucosa

The OCT image of a dysplastic lesion parallels histopathological status, showing epithelial thickening, loss of stratification in lower epithelium, epithelial down growth and loss of epithelial stratification as compared to healthy oral mucosa.[3]

Hard Dental Tissues

1. *Carious Lesions:*

The OCT image is represented by a strong backscattering region on the tooth surface in the fissure area. The depth of a carious lesion is sometimes very difficult to ascertain just by visual observation of the tooth surface for example in cases of secondary carious lesions[2].

2. *Noncarious Lesions:*

Occlusal overload can result in tooth attrition, micro- fractures on the enamel, failure of dental restorations, temporo-mandibular joint disorders etc. In these cases an initial diagnosis plays a very important role which can be made correctly using OCT.

Dental Fillings

The structural quality of the different restorations can be assessed with the help of OCT. Silver amalgam, tooth color materials like composite resin and compomer are the restorative materials that are used commonly for restoration of teeth. Silver amalgam being a metal completely obscures the structures present beneath it, while other tooth color restorative materials are less dense and hence allows to visualise the structures that are present below them.[4]

EndodonticTreatments

Areas of apical microleakage can be detected between the gutta-percha cones , the root canal walls and the filling material of the root canal space .

Temporo-Mandibular Joint Disc

The tempero-mandibular joint disc can be assessed precisely using optical coherence tomography.[5]

Periodontology

OCT is particularly helpful for periodontal diagnosis, generating ultrahigh resolution cross sectional images of dental tissues. The morphology of periodontal pocket and the soft tissue attachment level which are the indicator of disease progression can be easily observed with help of OCT. The thickness and characteristic of the gingiva, any irregularities on root surface, and the distribution of subgingival calculus[3] is provided quantitatively using this imaging modality.

Orthodontics

Sinescu C. et al used OCT system to evaluate connection between the bracket and the tooth structure. The quality of restoration done for bonding can be assessed as voids can be observed in restorative material in case of improper restoration. Also, a lack of adhesive material on the side of the bracket can be identified. It suggested that tooth-bracket interfaces could also be imaged in vivo[6].

Implantology

OCT images give quantitative information

regarding microstructural architecture, including the character of the gingiva as well as that of the implant and the soft tissue relationships. Improved clinical evaluation of periimplant soft tissues and significant advantages over existing diagnostic procedures is provided.

Prosthodontics

The evaluation of prosthesis particularly fixed partial prosthesis done by this imaging technique have accurately shown many defects which can lead to their deterioration and hence the quality of fixed partial prosthesis can be assessed easily and accurately.[7] These defects are usually located inside the material and cannot be depicted visually or by other conventional imagistic method.

Discussion

In vivo and in vitro imaging of hard and soft tissue of the human oral cavity has been demonstrated using different OCT techniques. Several types of oral mucosa and healthy and damaged tooth structures can be imaged and differentiated. OCT is an efficient diagnostic tool in periodontal diseases and dental restorative procedures. OCT imaging proved that laser-assisted endodontic treatment improved the prognosis of root canal filling and led to a reduction in the apical microleakage. In measurement of demineralization inhibition, results obtained suggest that (PS-OCT) is well suited for the non-destructive assessment of caries inhibition by anti-caries agents[8].

Studies, directed towards assessing the quality of dental prosthesis, as mentioned in this review, show the importance of adopting noninvasive methods of investigation, like OCT.

It was demonstrated that OCT represents a viable solution for investigating all sorts of dental prosthesis before their insertion into the oral cavity. OCT could act as a valuable tool in analyzing the integrity of prostheses, saving time and resources. In comparison with all other invasive and noninvasive imaging technologies, OCT proves to be a safer method exhibiting the highest resolution in depth .

Conclusion

Optical coherent tomography represents a novel diagnostic procedure for evaluation and assessment of the oral soft tissues and the hard dental structures. It can be used for evaluation of dental treatments reducing their failure rate and saving time and resources, by eliminating incorrect restorations before their insertion in the oral cavity. The unique capabilities of OCT recommend this technology for fundamental research and clinical practice. The review was based on reports on OCT directed towards both, the practice of dental medicine as well as to its associated research. To conclude with, OCT is a non-invasive, accurate, less time consuming diagnostic procedure which surpasses the current x ray technique, in terms of capabilities of resolution. We visualize continuous progress in advancing OCT into a widely used investigative tool in dentistry.

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