MICROSTRUCTURAL CHARACTERIZATION OF NON-CARIOUS CERVICAL LESIONS BY EN FACE OPTICAL COHERENCE TOMOGRAPHY

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Aim and objective. Non-carious cervical lesions (NCCL) are defined as the loss of tooth substance at the cemento-enamel junction. They are attributed to abrasion, erosion and/or eccentric occlusal overload. In order to evaluate the importance of occlusal factors in the etiology of NCCL, we investigated extracted frontal teeth by en face optical coherence tomography (eFOCT). Materials and methods. 35 frontal teeth, derived from patients with active bruxism and eccentric occlusal interferences, presented early NCCL on the labial surfaces. The other 5 frontal teeth had a normal crown morphology and were not exposed to occlusal overload before extraction. The dental samples were investigated using eFOCT operated in B-scan and C-scan mode. The eFOCT employs a low coherence source at 1300 nm. Results. Frontal teeth with normal crown morphology had a homogeneous microstructure of the cervical hard tissues on eFOCT images. The eFOCT investigation revealed a characteristic pattern of cracks in the area of NCCL of occlusal overloaded frontal teeth. Conclusions. eFOCT is an imaging technique that effectively identifies the microstructural effects of occlusal overload on the cervical hard tissues of frontal teeth.

Key words: non-carious cervical lesions, abfraction, occlusal overload, bruxism, en face optical coherence tomography

INTRODUCTION

Non-carious cervical lesions (NCCL) are defined as the loss of tooth substance at the cemento-enamel junction.¹ These lesions can be classified according to their primary etiology as: erosion, abrasion and abfraction.

Erosion is the progressive loss of tooth substance by chemical action, not involving bacteria.¹² The source of the acid can be either intrinsic (regurgitation of gastric acids, as occurs with eating disorders, such as anorexia and bulimia nervosa) or extrinsic (carbonated soft drinks, citrus fruits or juices). Abrasion is the pathological wear of tooth substance through some unusual or abnormal mechanical process (eg, excessive...
Horizontal toothbrushing. Abfraction is the pathologic loss of cervical hard dental tissues caused by biomechanical loading forces. Such loss is thought to be due to flexure and chemical fatigue degradation of enamel and/or dentin at some location distant from the actual point of loading.

Unfortunatelly, cervical lesions can results from several simultaneous etiologic factors. The differential diagnosis of NCCL is very difficult and is generally based on: a thorough anamnesis (age, diet, oral hygiene routine, abnormal oral habits, the patient's medical and dental history), the morphologic characteristics of the lesion (Fig. 1), an occlusal analysis searching signs of primary occlusal trauma.

The present study was focused on the microstructural characterization of early NCCL by en face optical coherence tomography (eFOCT), a new non-invasive imaging technique that can offer useful diagnostic information regarding the presence of occlusal overload.

MATERIALS AND METHODS

eFOCT was used to investigate:
– 35 frontal teeth with early NCCL lesions, derived from patients with active bruxism and eccentric occlusal interferences;
– 5 frontal teeth with normal crown morphology, extracted from patients without parafunction (control group).

Active bruxism was diagnosed by means of BiteStrip devices.

The dental samples were investigated using eFOCT operated in B-scan and C-scan mode. It generates 250 slices/ C-scan investigation, with a penetration depth of 2.5 mm in air. The dental samples were positioned with the labial and interproximal surfaces towards the scanner (Fig. 2). The eFOCT employs a low coherence source at 1300 nm. The details of our experimental set-up are presented in fig 3.

RESULTS

The eFOCT investigation of the cervical areas of frontal teeth with a normal crown morphology revealed a homogeneous microstructure of the dental hard tissues.
Frontal teeth with early NCCL presented on C-scan OCT images a characteristic pattern of cracks with a V shaped orientation, but not penetrating the tooth surface (Fig. 4). The large cracks, limited inside the cervical dental tissues, can be identified also on B-scan OCT images made at the cemento-enamel junction (Fig. 5).

**DISCUSSIONS**

eFOCT is a low-coherence interferometric imaging technique that performs high resolution (20 µm), cross-sectional tomographic imaging of tissue microstructure. The light is able to penetrate into the tissues without harmful effects. Differences in the refraction of the near infrared light are used to generate a signal that corresponds to the morphology and composition of the analysed tissues. OCT was used for the first time in ophthalmology, than later in cardiology, gastro-enterology. This non-invasive imaging method was recently introduced in dental medicine for:

- measuring the mineralization/demineralization degree of hard tissues in carious lesions;
- investigating the accuracy of dental restoration, by visualizing the tooth – restoration interface;
- *in vitro* detection of defects in ceramic materials and in reinforced complete dentures, analysis of the bone – implant interface;
- investigation of apical microleakage after laser-assisted endodontic treatment.

Our research team proved, in several previous studies, that OCT allows the identification of a characteristic microstructural pattern in frontal teeth with various degrees of dental wear and the early detection of occlusal overload in anterior teeth. These studies were focused on the incisal hard tissues of the occlusal overloaded teeth derived from patients with bruxism. Occlusal overload generated a characteristic pattern of cracks inside the enamel layer.
The present study used eFOCT to investigate another critical area of occlusal overloaded frontal teeth: the cervical buccal/labial region. The pathologic loss of cervical dental hard tissues due to biomechanical occlusal overload (eg, bruxism, occlusal interferences in latero/mediotruzion) is named abfraction. The high eccentric occlusal forces cause flexure of the cervical enamel and/or dentin. The cyclic occurrence of compression and tension may lead to rupture of the chemical bonds between the hydroxyapatite crystals, resulting in the loss of cervical hard tissues.\(^{15-17}\)

In order to identify the role of occlusal overload in the etiology of abfractions, we investigated, by en face OCT, 35 extracted frontal teeth with early NCCL, derived from patients with active bruxism and eccentric occlusal interferences. The C-scan OCT images revealed characteristic cracks, with a V shaped orientation, but not penetrating the tooth surface (when the samples were analyzed from the proximal surface). The B –scan OCT images identified also large cracks, limited inside the dental hard tissues (when the samples were investigated from the buccal surface, 1 mm above the cement-enamel junction). But the eFOCT investigation of the cervical areas of frontal teeth with a normal crown morphology revealed a homogeneous microstructure of the hard tissues. The microstructural parameters of the cervical hard tissues observed on OCT images allow the identification of occlusal overload as an etiologic factor in the early NCCL.

Future in vivo studies are necessary to evaluate the role of eFOCT in the differential diagnosis of abrasion with erosion and abrasion in cases of NCCL with a complex morphology. In this way the practitioner will avoid useless irreversible occlusal treatment (eg, selective grinding).

**CONCLUSIONS**

eFOCT is an imaging technique that effectively identifies the microstructural effects of occlusal overload on the cervical hard tissues of frontal teeth.

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