EN FACE OPTICAL COHERENCE TOMOGRAPHY INVESTIGATION OF PATHOLOGICAL DENTAL WEAR

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REZUMAT

Scop și obiective. Uzurile dentare exagerate (atriție patologică și abfracții) constituie o complicație frecventă a suprasolicitării ocluzale. Atriția patologică este provocată de contactele dento-dentare intense din timpul parafuncțiilor, fiind localizată la nivelul suprafețelor ocluzale. În schimb abfracțiile sunt pierderi patologice de substanța dură dentară din regiunea cervicală, care apar sub acțiunea unor forțe ocluzale exagerate și para-axiale. Studiul de față propune caracterizarea microstructurală a dinților frontali cu uzuri dentare patologice prin tomografie optic coerentă en face (eFTOC). **Material și metodă.** 42 de dinți frontali extrași au fost examinați prin eFTOC. 35 dintre ei au provenit de la pacienți cu un bruxism excentric activ (diagnosticat prin dispozitive BiteStrip), au prezentat abfracții adânci și grade variabile de atriție patologică. Ceilalți 7 dinți frontali, cu o morfologie coronară normală, nu au fost expuși pre-extracțional la suprasolicitări ocluzale. Probele dentare au fost investigate prin eFTOC la 1300 nm (B-scan și C-scan). **Rezultate.** Examinarea prin eFTOC a dinților frontali cu o morfologie coronară normală a relevat o structură omogenă a smaltului cervical și a celui ocluzal. Pe imaginile de TOC provenite de la dinții suprasolicitați ocluzal au fost identificate pierderi în formă de ic ale smaltului cervical și leziuni microstructurale în dentina subiacentă. Forțele ocluzale exagerate au produs fisuri largi, cu un tipar caracteristic, care penetrează țesuturile dure dentare până la nivelul suprafeței ocluzale. **Concluzii.** eFTOC este o metodă imagistică utilă pentru caracterizarea microstructurală a dinților frontali cu uzuri patologice. Ea permite de asemenea monitorizarea evoluției în timp a acestor uzuri.
Cuvinte cheie: atriție patologică, abfracție, suprasolicitare ocluzală, tomografie optic coerentă en face.

ABSTRACT

Aim and objectives. Excessive dental wear (pathological attrition and abfractions) is a frequent complication of occlusal overload. Pathological attrition results from mechanical wear during parafunction and is limited to the contacting surfaces of opposing teeth. Abfraction is the pathological loss of cervical hard tooth substance caused by biomechanical loading forces. The present study proposes the microstructural characterization of frontal teeth with pathological dental wear by en face optical coherence tomography (eFOCT). **Materials and methods:** 42 extracted frontal teeth were investigated using eFOCT. 35 teeth derived from patients with active eccentric bruxism (diagnosed by BiteStrip devices) and presented deep abfractions and variable degrees of occlusal pathological attrition. The other 7 frontal teeth, with a normal morphology of dental crowns, were not exposed to occlusal overload before extraction. The dental samples were investigated using a OCT device operating at 1300 nm (B-scan and C-scan mode). **Results.** The eFOCT investigation of frontal teeth with a normal morphology revealed a homogeneous structure of the occlusal and cervical enamel. The OCT images obtained from the occlusal overloaded frontal teeth visualized the wedge-shaped loss of cervical enamel and damage in the microstructure of the underlying dentin. The high occlusal forces produced also characteristic pattern of large cracks, which reached the occlusal tooth surface. **Conclusions:** eFOCT is a useful imaging method for the microstructural characterization of frontal teeth with pathological wear. It allows also the monitoring of the wear process.
Key words: pathological attrition, abfraction, occlusal overload, en face optical coherence tomography

INTRODUCTION

Optical coherence tomography (OCT) is a new non-invasive imaging technique. It performs high resolution, cross-sectional tomographic imaging of tissue microstructure. The resolution of OCT (20 μm) is much better than that of Xray- (50 μm) or ultrasound investigation (110 μm).

OCT was first used in ophtalmology, but recently it was also introduced in dental medicine.[1-7] In previous studies, we used OCT to identify a a characteristic microstructural pattern in frontal teeth with various degrees of dental wear and the early detection of occlusal overload in anterior teeth.[8-10] These studies were focused on

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Received for publication: Oct. 14, 2009. Revised: Dec. 17, 2009.

the incisal hard tissues of the occlusal overloaded teeth derived from bruxing patients.

But the high occlusal forces generated during bruxism can produce two types of pathological dental wear: pathological attrition, located on the contacting surfaces of opposing teeth (Fig. 1a) and abfractions, in the cervical area of buccal/ lingual tooth surfaces (Fig. 1b).[11,12]

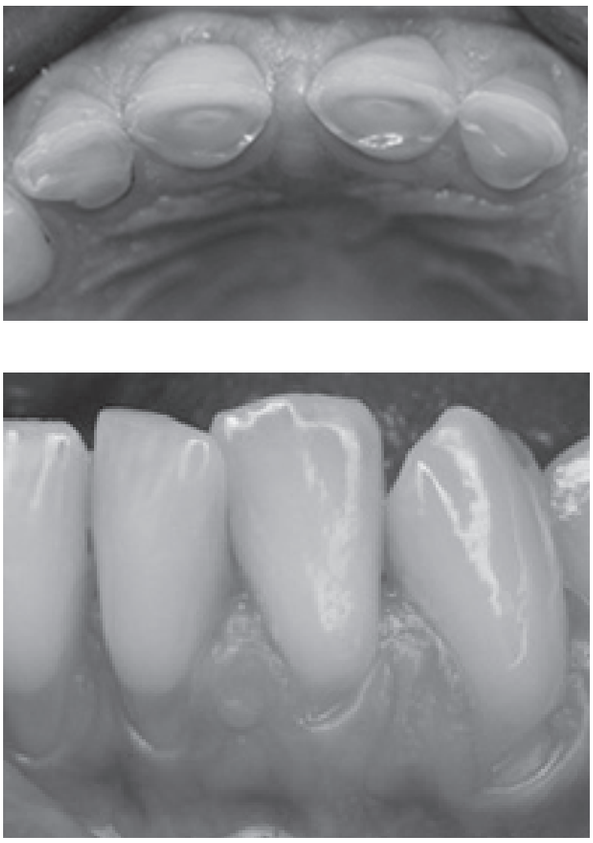

Figure 1. Pathological dental wear in bruxing patients: a. pathological attrition on maxillary incisors; b. abfractions on the labial surface of mandibular frontal teeth.

The present en face optical coherence tomography (eFOCT) investigation will make a microstructural subsurface characterization of incisal and cervical dental hard tissues, which were subjected to occlusal overload before the extraction of frontal teeth.

MATERIALS AND METHODS

*eF*OCT was applied to 42 extracted frontal teeth. The method visualized the subsurface microstructural characteristics of the incisal and cervical dental hard tissues. The dental samples were positioned with the buccal and interproximal surfaces towards the scanner (Fig. 2).

Figure 2. Sample 1 ready to be scanned by eFOCT technology

35 of the examined frontal teeth derived from patients with active bruxism (screened by means of Bite Strip devices) and 7 from subjects without parafunction. The bruxing patients teeth presented variable degrees of wear (Tooth wear index of Smith and Knight = 1-3). We considered that the attrition was pathological because all patients were under 30 years of age.

The dental samples were investigated using *eF*OCT (B-scan and C-scan mode). The *eF*OCT device is working on 1300 nm, with a laser guided beam (Fig. 3). It generates 250 slices/ C-scan investigation, with a penetration depth of 2,5 mm in air.

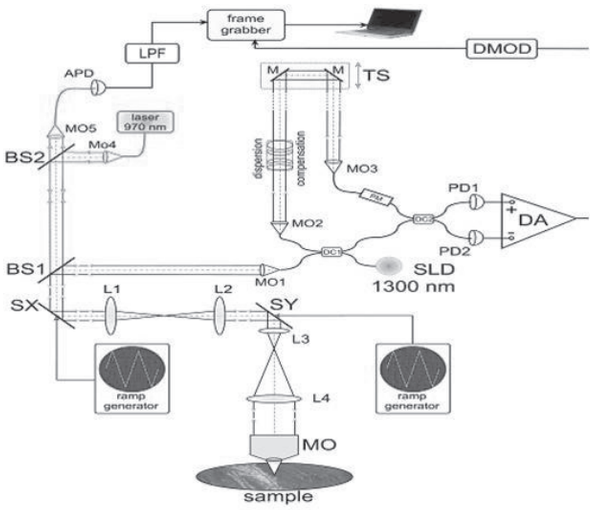

Figure 3. Experimental set-up used for eFOCT, including a super luminescent diode (SLD) emitting at 1300 nm with a bandwidth of 65 nm (DC1 and DC2 – directional couplers; MO1 and MO2 – arms of the interferometer; BS1 - dichroic beam-splitter; SX and SY - galvanometer scanners; DA - balanced photodetection unit; TS - computer driven translation stage)

RESULTS

The eFOCT investigation of the 7 frontal teeth derived from patients without bruxism revealed a homogeneous structure of the incisal and cervical hard tissues.

The occlusal overloaded frontal teeth, derived from patients with active eccentric bruxism, revealed damage in the microstructure of the incisal superficial hard tissues. The high occlusal forces produced a characteristic pattern of large cracks, which reached the tooth surface.

The C-scan OCT investigation of the labial cervical area revealed a V shaped dental hard tissues loss and cracks that are reaching the tooth surface (Fig. 4 and Fig. 5). This microstructural pattern of the occlusal overloaded frontal teeth can be identified also on B-scan OCT images (Fig. 6).

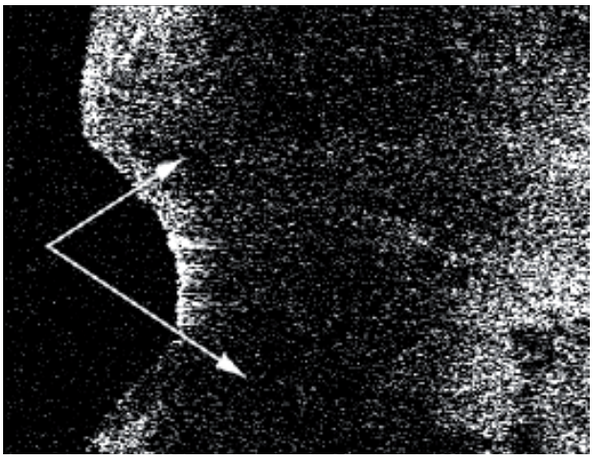

Figure 4. C-scan OCT image of sample 1 (investigated from the interproximal surface): V shaped dental hard tissues loss in the labial cervical area, with cracks (white arrows) that are reaching the tooth surface (lateral image size 4mm x 4mm, at a depth of 600 microns from the top measured in air); the OCT image is not zoomed.

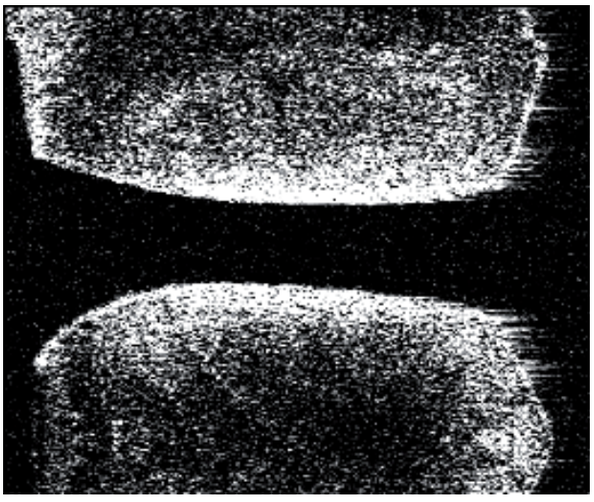

Figure 5. C-scan OCT image of sample 3 (investigated from the labial surface): microstructural defects in the dental hard tissues above and below the cemento-enamel jonction (lateral image size 4mm x 4mm, at a depth of 250 microns from the top measured in air); the OCT image is not zoomed.

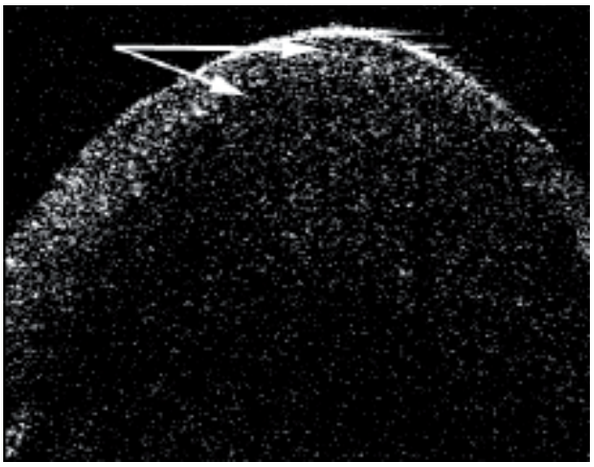

Figure 6. B-scan OCT image of sample 3 (investigated from the buccal surface): cracks (white arrows) in the dental hard tissues above the cemento-enamel jonction, that are reaching the tooth surface - lateral image size 4 mm (horizontal), axial size 2 mm measured in air (vertical).

DISCUSSIONS

Bruxism is the forceful involuntary and subconsciously grinding or clenching of teeth, during the waking state or sleep.[11] This parafunction causes heavy occlusal loads (1000 N), which surpass by far the masticatory occlusal forces (10 -20 N).[13] These heavy forces are applied to the teeth as the mandible shifts from side to side. This shifting causes horizontal and oblique forces, which can lead to abfractions and pathological attrition.[14] In addition, bruxist have a total tooth contact time of 30 min – 3 h/24h. For patients without parafunction, the tooth contact time (for normal chewing and swallowing) is 10 min. This is why we considered that teeth derived from patients with active bruxism were subjected to occlusal overload before extraction.

The occlusal overloaded frontal teeth revealed damage in the microstructure of the incisal superficial hard tissues on *eF*OCT images. The high occlusal forces produced a characteristic pattern of large cracks, which reached the tooth surface. These data were in accordance with the results of our previous study, focused on frontal teeth with various degrees of wear.[8]

New interesting data arrised from the *eF*OCT investigation of the abfractions located on the labial surfaces of the occlusal overloaded frontal teeth. The C-scan OCT images of the labial cervical area revealed a V shaped dental hard tissues loss and cracks that are reaching the tooth surface. These cracks were also identified on the B-scan OCT images of the same teeth. The microstructural signs of occlusal overload identified in the incisal dental tissues are associated

with a characteristic pattern of cracks in the cervical region of the same tooth.

Within the limitations of our study, the findings of this *eF*OCT investigation support the occlusal trauma concept in the etiology of abfractions.[15,16,17] High eccentric occlusal forces cause flexure of the cervical enamel and/or dentin; the consecutive cervical stress concentration can produce fracture lines (cracks) in the dental hard tissues at the cemento-enamel jonction, with the ultimate loss of these tissues. Further OCT studies are necessary to support this preliminary findings.

CONCLUSIONS

*eF*OCT is a promising noninvasive technique for the detection and monitoring of the effects of occlusal overload on the incisal and cervical hard tissues of frontal teeth. This imaging technique allows the in real time visualization of microstructural particularities which can not be identified by other imaging techniques.

ACKNOWLEDGMENT

This study was sponsored by grant nr.8848 (1.10.2009 – 30.09.2010) – Victor Babes University of Medicine and Pharmacy Timisoara. We also acknowledge the support of the University of Kent.

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