

Evaluation of the Prognosis of Compomer Class V Restorations through *en face* Optical Coherence Tomography

CORINA MARCAUTEANU¹, MEDA - LAVINIA NEGRUTIU^{2*}, LAVINIA ARDELEAN³, LAURA CRISTINA RUSU³, ADRIAN GH. PODOLEANU⁴

¹ University of Medicine and Pharmacy "Victor Babeş" Timisoara, Faculty of Dentistry, Department of Occlusion, 9 Revolutiei Blv., 300070, Timisoara, Romania

² University of Medicine and Pharmacy "Victor Babeş" Timisoara, Department of Prostheses Technology and Dental Materials, 9 Revolutiei Blv., 300070, Timisoara, Romania

³ University of Medicine and Pharmacy "Victor Babeş" Timisoara, 9 Revolutiei Blv., 300070, Timisoara, Romania

⁴ Applied Optics Group, School of Physical Sciences, University of Kent, Canterbury, UK

Compomer class V restoration is the treatment of choice in noncarious cervical lesions. Unfortunately, these lesions differ in terms of dentine adhesion quality. Abfractions are characterized by sclerotic dentine, which makes bonding of composite restorations very difficult. We propose the evaluation of abfractions by means of en face optical coherence tomography (eFOCT), before the placement of restorations. The dental samples were investigated using an eFOCT system operating at 1300 nm in B-scan and C-scan mode. The eFOCT images obtained from the teeth with buccal abfractions visualized cracks in the underlying dentine, which reached the tooth surface. The μ CT and histological images confirmed the microstructural defects identified on eFOCT images. The time - domain OCT system we used was not able to visualize the layer of sclerotic dentine on the surface of buccal abfractions. In conclusion, eFOCT is a promising noninvasive imaging method for the detection of an overload aetiology in buccal abfractions. The compomer class V restorations will have a poor prognosis if they are placed before or without an occlusal equilibration.

Keywords: class V restorations, sclerotic dentine, biotechnology, en face optical coherence tomography

Compomer class V restoration is the treatment of choice in noncarious cervical lesions. The special properties of compomer materials (Dyract eXtra from Dentsply) result from the combination of fluoridated glass filler with acid-modified monomers. They have a good adhesion to dentine and release fluoride ions continually, functioning as acid-buffers along the interface with the tooth structure.

Unfortunately, noncarious cervical lesions differ in terms of dentine adhesion quality. Abfractions and erosions do not have the same dentine characteristics. This feature is derived from the presence of sclerotic dentine on the surface of abfractions. The pathologic loss of hard tooth substance at the cemento-enamel junction, caused by biomechanical occlusal overload [1-4], is accompanied by progressive deposition of intratubular dentine. The obliteration of several tubules in the adjacent areas leads to sclerotic dentine, with a glassy appearance [5]. The difficulty in bonding composite restorations to this type of dentine is well known in the dental literature [6]. Persistence occlusal overload can also lead to restoration failure.

We propose the evaluation of the noncarious cervical lesions by means of *en face* optical coherence tomography (eFOCT), before the placement of restorations. We would like to know if the layer of highly mineralized, sclerotic dentine can be identified on OCT images. The presence of this layer could indicate a persistent occlusal overload, which must be eliminated before the restorative treatment.

Experimental part

Materials and methods

20 extracted teeth were investigated using eFOCT (fig. 1). 10 teeth derived from patients with active bruxism (identified through BiteStrip devices); they presented deep

buccal abfractions (wedge-shaped cervical lesions, with a sharp borderline in the occlusal/incisal intact enamel). Abfractions are a frequent complication in bruxing patients [7]. Bruxism consists of forceful involuntary and subconscious grinding or clenching of teeth during the waking state or sleep and can lead to occlusal overload.

The other 10 teeth were not exposed to occlusal overload in the past and had a normal morphology of the dental crowns.

The dental samples were investigated using an eFOCT system (fig. 2) operating at 1300 nm (B-scan at 1 Hz and C-scan mode at 2 Hz). The system has a depth resolution of less than 10 μ m in tissue. The teeth were positioned with the buccal and interproximal surfaces towards the scanner. The experimental set-up of the eFOCT investigation (fig. 2) included a SLD (super luminescent diode) emitting at 1300 nm with a bandwidth of 65 nm, which determined a depth resolution in tissue at less than

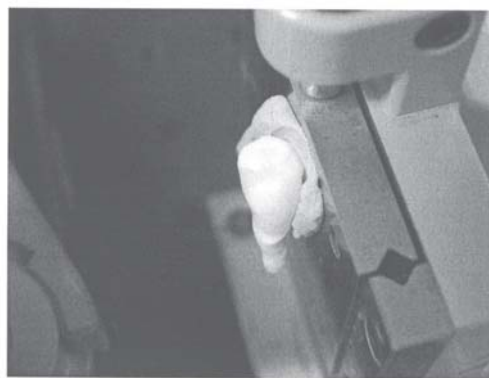


Fig. 1. Sample 7 in front of the scanning device. Aspect from the eFOCT investigation

* email: meda_negrutiu@yahoo.com; Tel.: 0040 722700593

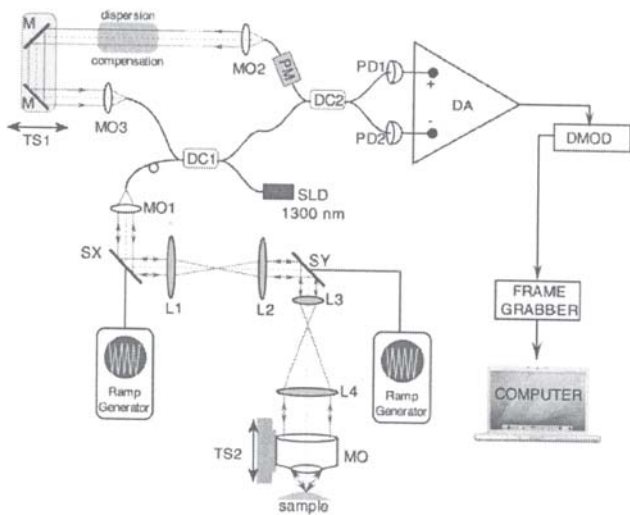


Fig. 2. eFOCT system operating at 1300 nm

10 μm . This configuration can work in two regimes of operation: C-scan mode (C-scans are made from many T-scans along X at 500 Hz; frame rate: 2 Hz; TS1 is fixed) and B-scan mode (no voltage to SY).

eFOCT images were further compared with micro-computer tomography (μCT) images and histological sections.

The dental samples were scanned using cone beam μCT [8]. The cone-beam μCT scanner consists of a micro-focal spot x-ray tube (10-20 μm), xyz-rotary stage, and a micro-angiographic detector with a 45 microns pixel size. The x-ray exposure parameters were: 40 kVp, 1 mA and 300 ms exposure per frame. The samples were placed onto the rotary stage at a magnification between 2 and 1.1 depending on the sample size and scanned using one

degree step increments. After projection acquisition they were reconstructed using a $(512)^3$ volume with a 45 microns³ per voxel.

The teeth were further prepared for the histological examination according to a detailed working protocol (Technovit 9100 New system). The dental samples were sectioned using the diamond blade of the Leica SP 1600 microtome and examined using an Olympus CX41 microscope. Images were captured with an Olympus digital camera.

Results and discussions

The eFOCT investigation of teeth with a normal morphology, and not exposed to high occlusal forces in the past, revealed a homogeneous structure of the cervical dental hard tissues. The cervical enamel is very thin or lacks completely.

The C-scan and B-scan images obtained from the teeth with deep buccal abfractions visualized damage in the microstructure of these tissues. The high occlusal forces produced a characteristic pattern of structural defects. Multiple large cracks appeared in the dentine underlying the wedge-shaped loss of cervical dental hard tissues on C-scan and B-scan OCT images (fig. 3 and fig. 4). Most cracks were reaching the surface of the abfraction. The μCT (fig. 5) and histological images (fig. 6) confirmed the microstructural defects identified on eFOCT images.

Unfortunately, no differences were observed between normal and sclerotic dentine on eFOCT images.

Optical coherence tomography is largely used in dental medicine [9 - 11]. Our team used this noninvasive imaging technique for: the quality assessment of dental treatments [12], analysis of the bone - implant interface [13], visualization of defects in reinforced complete dentures [14], magistic evaluation of direct dental restorations [15], investigation of apical microleakage after laser-assisted

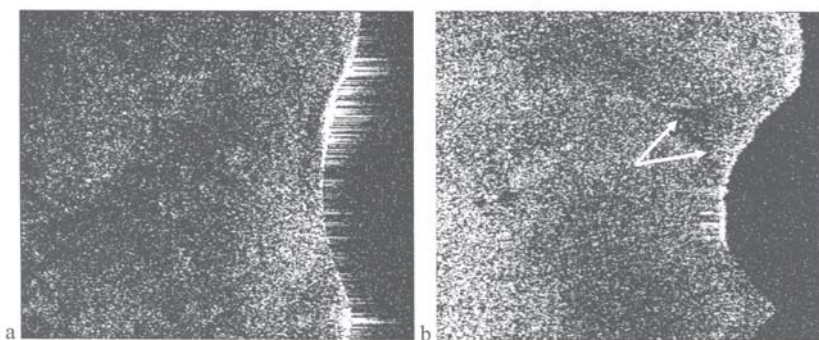


Fig. 3. C-scan images of sample 8 and 14 (investigated from the proximal surface): a. homogenous microstructure of the cervical dentine; b. the cracks (C) are penetrating the cervical dentine and are reaching at the surface of the abfraction (images size 2mmx2mm; (investigated 780 μ from the top measured in air)

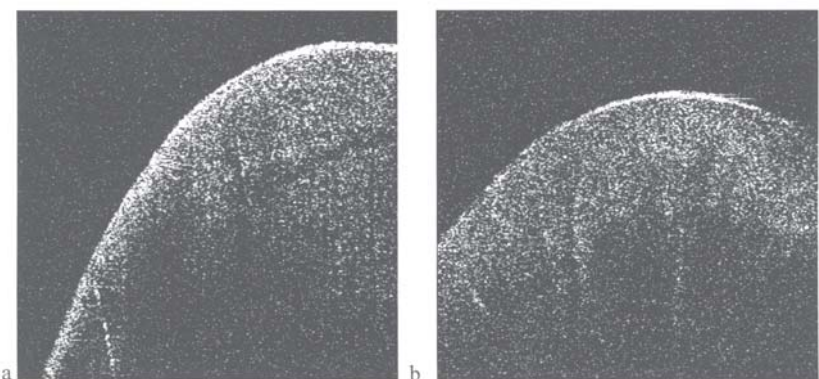


Fig. 4. B-scan OCT image of samples 10 and 11 (investigated from the buccal surface): a. homogenous microstructure of the dental hard tissues above the abfraction; b. the high occlusal forces produced microstructural defects (cracks - C) in the enamel and dentine just above the buccal abfraction; lateral images size 4 mm (horizontal), axial size 2mm measured in air).

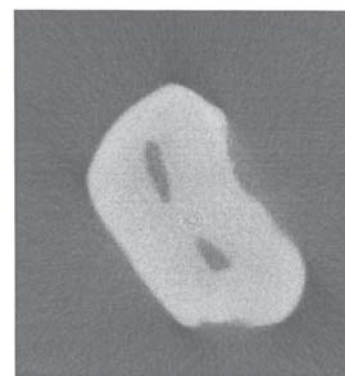


Fig. 5. Micro - computer tomography image of sample 1 at the cemento-enamel junction: micro structural defects (cracks - C) in the remaining dentine of the buccal abfraction.

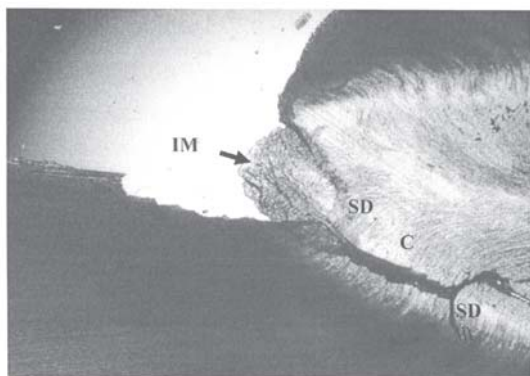


Fig. 6. The histological section (sample 1) confirmed the microstructural defects observed on *eFOCT* images – nativ, x400. Most cracks (C) did reach the surface of the cervical dentine. Large areas of sclerotic dentine (SD) are also visible. IM represents the inclusion material.

endodontic treatment [16], microstructural characterization of teeth with various degrees of attrition [17-19].

In this study we propose the microstructural characterization of the cervical dentine by *eFOCT*. The teeth with a normal crown morphology were not occlusal overloaded in the past and presented a homogenous microstructure of the cervical dentine. The teeth with buccal abfractions, derived from patients with bruxism, had a characteristic pattern of cracks, which reached the surface of the cervical dentine. Bruxism can cause heavy occlusal loads (800 N – 1000 N); in addition, bruxing patients have a longer tooth contact time than non-bruxing subjects (30 min – 3h/24h). The best results were obtained on C-scan OCT images, when the samples were investigated from the proximal surface, and on B-scan OCT images, when the investigation was performed from the buccal surface of the teeth. Sequential and rapid switching between the *en Face* regime and the cross-section regime, specific for the *eFOCT* systems developed by us, represents a significant advantage in the non-invasive imaging.

The μ CT and histological images confirmed the microstructural defects identified on *eFOCT* images.

The persistence of occlusal overload facilitates the propagation of these defects in the cervical dental hard tissues and may lead to the restoration failure. The histological examination revealed that the cracks are surrounded by localised areas of sclerotic, hyper-mineralised, dentine. The sclerotic dentine has a lower resistance to fracture than normal dentine.

Balooch and colab. [20] suggest differences between local mechanical and optical properties of normal and transparent root dentin. Unfortunately, no differences were observed between normal and sclerotic dentine on *eFOCT* images.

Conclusions

eFOCT is a promising noninvasive imaging method for the detection of an overload aetiology in buccal abfractions. The compomer class V restorations will have a poor prognosis if they are placed before or without an occlusal equilibration. The time – domain OCT system we used was not able to visualize the layer of sclerotic dentine on the surface of buccal abfractions.

Acknowledgements: This study was supported by CNCSIS -UEFISCSU, project PNII-IDEI, nr. 1754/2008. We also acknowledge the support of the University of Kent.

References

1. THE ACADEMY OF PROSTHODONTICS, Eighth Edition, Mosby, 2005.
2. GRIPPO, J.O. , J Esthet Dent , 3, 1991, p. 14 – 19.
3. LEE, W.C., EAKLE, W.S., J Prosthet Dent ,52, 1084
4. REES, J.S., J Oral Rehabil, 29, 2002, p. 188 -193.
5. ADDY, M., EMBERY, G., EDGAR W.M., ORCHARDSON R., 1 Edition, Informa Healthcare, United Kingdom, 2000, p. 10, 11,13.
6. TAY, F.R., PASHLEY, D.H., Journal of Dentistry, 32, 2004, p. 173 – 196.
7. MĂRCĂUEANU, C., BRATU, D., STOICA, E.T., NEGRUIU, M., SINESCU, C., IANĂ, E., et al. 1 Edition, Eurobit Publishing, Romania, 2010.
8. IONIȚĂ, C.N., HOFFMANN, K.R., BEDNAREK, D.R., CHITYALA, R., RUDIN, R., J Digit Imaging, 21, nr. 3, 2008, p. 296–305.
9. PODOLEANU AG, ROSEN RB., Progress in Retinal and Eye Research, 27, 2008, p. 464-499.
10. PODOLEANU, A. GH, SEEGER, M., DOBRE, G.M., et al, J Biomed Opt, 3, 1998, p. 12 -20.
11. DUMA, V.F., ROLLAND, J.P., PODOLEANU, A. GH., Proc. SPIE, 7556, 2010, p. 75560B-1.
12. SINESCU, C., NEGRUIU M.L., TODEA, C., BĂLĂBUC, C., FILIP, L., ROMÎNU, R., BRADU, A., HUGHES, M., PODOLEANU, A. GH., J. Biomed. Opt., 13, 2008, p. 054 – 065.
13. SINESCU, C., HUGHES, M., BRADU, A., NEGRUȚIU, M., TODEA, C., ANTONIE, S., LAISSUE, PH., ROMINU, M., PODOLEANU, A.GH., Proc. SPIE, 6991, 2008, p. 69911L.
14. NEGRUȚIU, M., SINESCU, C., TODEA, C., PODOLEANU, A.GH., Proc SPIE, 6843, 2008, p. 68430R.
15. NEGRUIU, M.L., SINESCU, C., TOPALĂ, F., IONIĂ, C., MĂRCĂUEANU, C., PETRESCU, E.L., PODOLEANU, A. GH., Proc. SPIE –OSA, 8091, 2011, p. 80911T.
16. TODEA, C., BĂLĂBUC, C., SINESCU, C., FILIP, L., Kerezsi, C., CALNICEANU, M., NEGRUIU, M., BRADU, A., HUGHES, M., PODOLEANU, A.Gh., Lasers in Medical Science, 25, nr. 5, 2009, p. 29 – 639.
17. MĂRCĂUȚEANU, C., SINESCU, C., NEGRUȚIU, M., DEMJAN, E., DOBRE, G., PODOLEANU, A.GH., Medicina in evoluție, 3, 2008, p. 73
18. MĂRCĂUȚEANU, C., NEGRUȚIU, M., SINESCU, C. et al., Proc. SPIE, 7162, 2009, p. 716205.
19. MĂRCĂUȚEANU, C., NEGRUȚIU, M., SINESCU, C. et al., Proc. SPIE, 7372, 2009, p. 737227.
20. BALOOCH, M., DEMOS, S. G., KINNEY, J. H., MARSHALL, G. W. , BALOOCH G., MARSHALL, S. J., Journal of Materials Science: Materials in Medicine, 12, nr. 6, 2001, p. 507-514

Manuscript received: 17.12.2011