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Optical Coherence Tomography study regarding the enamel structure before and after debonding

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ABSTRACT

Orthodontic treatments imply the use of different types of adhesives and brackets. However, concerns have been raised regarding the effect of these treatments on the structure of the involved teeth. The debonding process is especially regarded as a concern: due to the use of different pliers tensile and pulling forces the developon the surface of the tooth. The finishing bur is also a concern.Optical Coherence Tomography (OCT), an emerging technology that performs transverse sections of biological systems has been used in order to obtain a more accurate assessment of enamel quality due to its wide applicability and to its non-invasive properties.OCT, analogous to ultrasound imaging(with the difference that it uses light instead of sound), provides cross-sectionalimages of the tissue structure on the micron scale,*in vivo*and in real time. Regarding fixed orthodontic treatments, patients are often subjected in the process to a high risk of enamel decalcification and carious processes. Demineralization usually occurs in the area adjacent to the orthodontic bracket location, where bacterial plaque control is difficult. Therefore, in this study we evaluate using OCT the degree of demineralisation produced in the enamel structure, following the removal of the orthodontic bracket. Also, the amount of adhesive remnants after the removal of the adhesive and the finishing of the dental surface with specific instrumentation is evaluated.

Keywords: Dental medicine, biomedical imaging, Optical Coherence Tomography (OCT),orthodontic treatments,demineralization, adhesives and brackets.

1. INTRODUCTION

Orthodontic treatments imply the use of different types of adhesives and brackets [1]. However, concerns have been raised regarding the effect of these treatments on the structure of the involved teeth. The debonding process is especially regarded as a concern: due to the use of different pliers tensile and pulling forces the develop on the surface of the tooth. The finishing bur is also a concern.

The aim of this work is to use for such a study Optical Coherence Tomography (OCT) [2-4], an emerging technology that performs transverse sections of biological systems which are then transposed into high resolution images for

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diagnostic interpretation. An OCT technique is analogous to that based on ultrasound imaging, with the difference that it uses light (i.e., infrared laser beams) instead of sound. It is able to provide cross-sectionalimages of the tissue structure on the micron scale *in vivo* or *in vitro*and in real time [5].

The use of OCT has been intensively studied. Many such studies have demonstrated its applicability in dentistry, since the late 1990s [6]. Current scientific literature shows that OCT has been successfully used for acquiring images for different purposes[7]: dental biofilm, attrited teeth, enamel erosion, dentin structures, vertical root fractures, and incipient carious lesions. It was also used for the evaluation of severity in advanced carious lesions and remineralization of root caries, dentin re-mineralization, lesion progress in root caries, for quantification of remineralization, as well as for determining the efficiency of different agents in the inhibition of demineralization [8].OCT has been used in order to obtain a more accurate assessment of enamel quality,because of its wide applicability and its non-invasive properties[9,10]. Additionally, several research groups have demonstrated that OCT is capable to evaluate the oral mucosa [7], the microleakages and internal defects of composite restorations, dental sealants and endodontic fillings, the root internal structure, the dental implant-abutment interface, and dental adhesives [11]. OCT is able to identify early signs of inflammation, unlikely to be detected by clinical examination. OCT imaging offers the exciting potential to detect periimplantitis before significant osseous destruction occurs. OCT has also been employed for periodontal diagnosis [12], for evaluating the integrity of dental prosthesis, their quality, their marginal fitting and their adhesion to the tooth structure [13,14]; also, for the assessment of dental procedures [15,16].

When it comes to the orthodontic field of practice, OCT has been put to use to study the effects of treatment on the periodontal ligament, the monitoring of demineralization peripheral to orthodontic brackets, and the effects of different bracket ligation types on plaque retention [17-19].During fixed orthodontic treatments, patients are often subjected to a high risk of enamel decalcification and carious processes. Demineralization usually occurs in the area adjacent to the orthodontic bracket location, where the control of the bacterial plaqueis difficult.

The purpose of the study is the evaluation, using OCT, of the enamel structure after the debonding procedure and after the removal of the excess adhesive with two different types of burs.

2. MATERIALS AND METHODS

In order to evaluate the degree of demineralisation of the enamel and the amount of adhesive remaining on its surface, two lower first premolars were selected. They were collated for 12 months with orthodontic brackets in a specialized treatment. Subsequently, after the removal of the orthodontic devices, they were extracted and immersed in 0.9% saline NaCl. Prior to the extraction, the devices were taken off using orthodontic pliers to separate the vestibular brackets. Dental surfaces were etched with 37% phosphoric acid for 20 s, followed by a 10s water wash and by air-jet drying.

The bonding procedure was done with TransbondPlusColor Change Adhesive (3M Unitek), according to the manufacturer's instructions. The primer was applied to the dental surface, and the adhesive was applied to the base of the brackets, and then they were placed on the vestibular surfaces of the teeth.

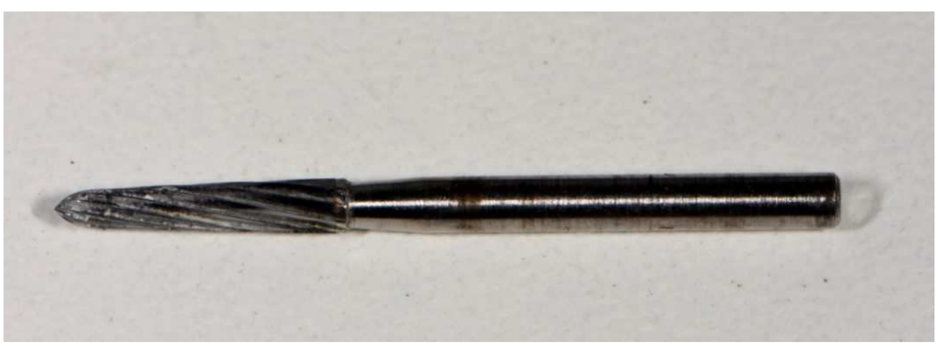


Figure 1.Tungsten carbide bur utilized to remove the remaining adhesive.

A 400 g dynamic pressure was applied prior to the photo-polymerization of the adhesive to standardize the thickness of the adhesive layer at the base of the bracket. The adhesive was light cured for 20 s on the incisal and cervical edges of the bracket using an Ortholux LED Curing Light (3M Unitek) lamp. After collapsing, the teeth were kept in the oral cavity until the extraction decision, then the take-off and immersion in the 0.9% saline solution was performed.

After the bracket removal, two lower premolars were set to be examined by OCT. Adhesive removal was carried out by using two types of burs: a high speed tungsten carbide bur (Intensive Swiss Dental Products) and a color code blue diamond bur.The study was conducted in the OCT Research Laboratory of *Victor Babes* University of Medicine and Pharmacy of Timisoara.Two OCT systems were used to evaluate the samples, obtaining a series of sections taken at a constant depth inside the sample (C-scans) and vertical sections (B-scans) of the targeted dental surfaces. The systems are connected to a pre-configured personal computer where the images are displayed and stored.

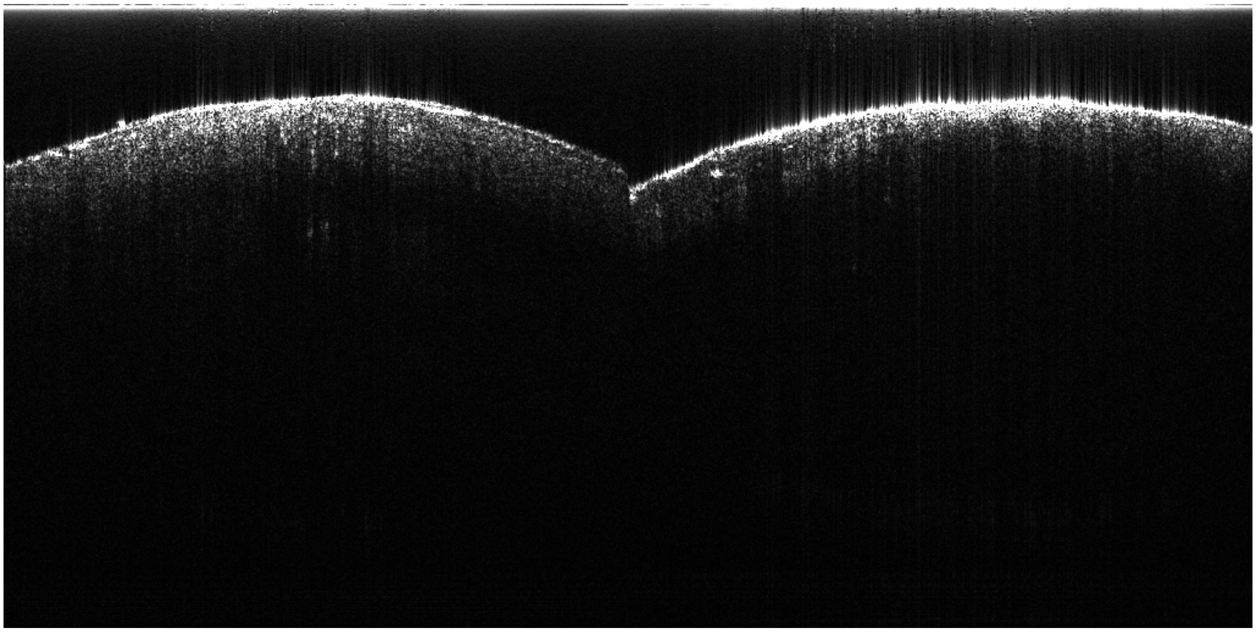
3. RESULTS AND DISCUSSION

When performing the OCT evaluation, the aim was to observe the integrity and the quality of the integral enamel in relation to the one affected by both the collapsing procedure (by using the orthodontic device) and the procedure of removingthe adhesive remaining in excess. As a result, three dental surfaces were evaluated using OCT, namely:

1. The vestibular dental surface treated with the debonding carbide tungsten moister.
2. The dental surface treated with the large grain (blue code) cutter subsequent to the debonding.
3. The lingual surface of one of the premolars, taken as a reference point for the integral enamel, unaffected by the debonding or milling finishing procedure.

Upon the initial visual inspection of the enamel structure after the removal of adhesive remnants, the tooth surfaces appeared clean and smooth. However, 2D OCT images allowed for the measurement of the enamel thickness and thus the evaluation of the damage that the different types of burs produced.There were no significant quantities of adhesive remnants upon the enamel surface left after the preparation.

Figure 2.Tooth position during the OCT evaluation – in front of a Time Domain (TD) in-house developed system.



(a) (b)

Figure 3.SD-OCT image of the bucal surface of the premolar upon which (a) the tungsten carbide bur and (b) the diamond bur was used.

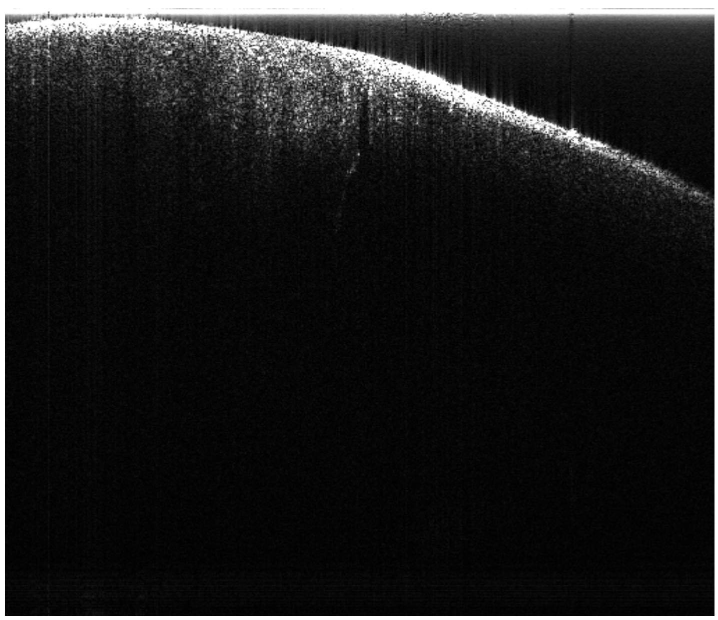


Figure 4.SD-OCT image of the lingual surface of one of the premolars which was taken as reference due to the fact that the enamel had not been affected by the debonding procedure of by any types of burs.

Loss of hard dental tissue could be observed in both cases of preparation techniques.The color code blue diamond bur was the most invasive method, resulting in the most damage produced to the enamel surface.

The 2D imaging performed made it possible to observe the remaining adhesive at the dental surface. The difference between the enamel and the residual resin can easily be detected using the 2D images obtained with OCT, as the light is strongly retrodifiable at the level of each medium within the sample. Thus, the increased brightness of the enamel-based interface can be observed without the need for a contrast agent. Thus, OCT imaging makes it possible to distinguish the dental structures from those of the residual resin.

Cracks and fractures in the tooth surface are risks that can be encountered when removing orthodontic appliances that cause both aesthetic and functional inconveniences. In addition to this situation, bracket fracture also represents a major concern that can hamper the removal of the remaining adhesive and polishing of the enamel. The purpose of this study was to demonstrate the use of OCT for the characterization of enamel structure after debonding and cleaning-up. In 2D OCT images it is possible to see the remaining adhesive on the enamel surface. The differentiation between enamel tissue and the non-biological material can clearly be seen on such OCT images. Because light is highly scattered at the boundary of each medium, the brightness intercepted at the enamel-adhesive interface is clearly visible without the use of a contrasting agent. Thus, with the use of OCT, visualization of resin remnants on the surface of the tooth after debonding is possible.

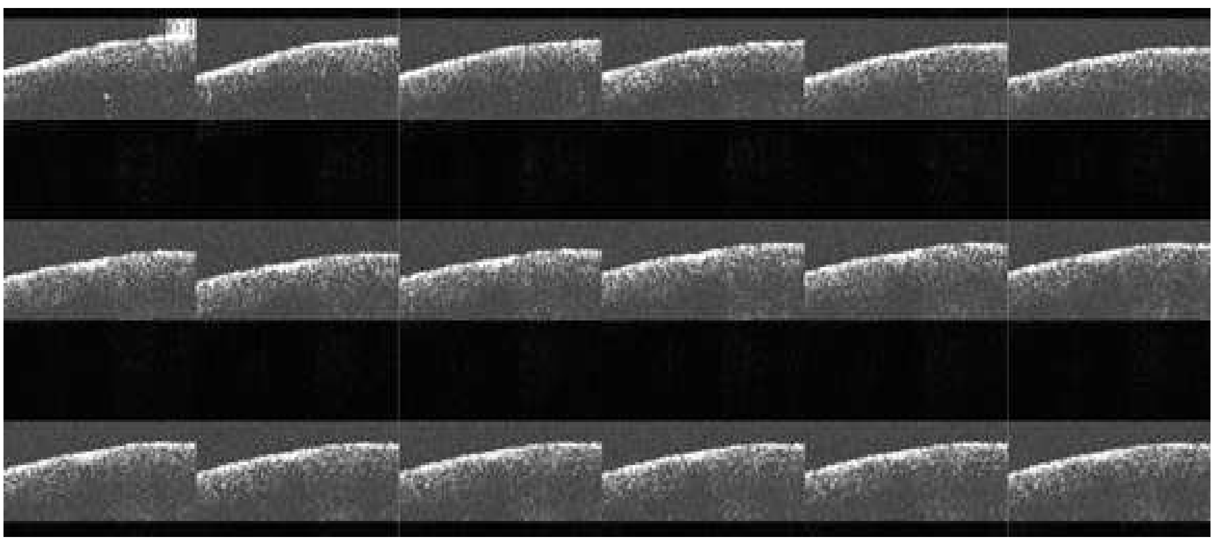


Figure 5.Series of B-scans of the lingual surface of one of the premolars taken as reference due to enamel integrity.

4. CONCLUSIONS

The enamel structure characterization after debonding can be performed successfully with optical coherencetomography. Optical coherence tomography technology has greatpotential for use in orthodontic research and can become a useful tool in clinical practice, since it is ableto assess the dental hard tissues noninvasively, superficially, and in depth. However, further efforts are still necessary to improve the technique and enable the clinical use of technology.

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