Evaluation of *In Vitro* Dental Restoration by Optical Coherence Tomography

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Optical coherence tomography (OCT) is a well established interferometric technique that performs high resolution, non-invasive, cross-sectional tomographic imaging of tissue microstructures and other biophotonics applications [1]. In Odontology, a series of reports first appeared in 1998 [2], with imaging of both hard and soft oral tissues. This led to several diagnostics of bucal diseases, including periodontal, early caries, among others. Dental caries is known as a multifactorial pathological process, characterized by hard tissue demineralization. Early diagnostics is thus desired. In this communication, we report the application of OCT to dental restoration evaluation, particularly analyzing failure gaps left after the restoration has been performed. Imaging resolution of 10-15 μm have been achieved and > 50 μm dental cavities are measured. Molar dental restorations on enamel of extracted teeth were performed using composite resin and amalgam as the restoring material. Failure gaps were set by using a 50 μm thick acetate tape during the restoration procedure. The results from the OCT were compared to two-dimensional images obtained with x-ray and optical microscope.

The basic experimental scheme for the OCT is similar to most set ups reported in the literature [1,2]. Femtosecond pulses, operating at 800 nm, were used to induce a spectral broadening in a nonlinear fiber. The initial spectral width of 10nm, were broadened to 41nm providing a depth spatial resolution of 10μm. The output light from the nonlinear fiber was directed to a 2X2 fiber coupler (50/50 @800nm) that composed the Michelson Interferometer. Both arms (the reference and sample) were set on computer controlled translation stages with 200nm minimum displacement steps. The collimated beam incident on the sample was focused using a 10cm focal distance length, providing a lateral resolution of 25μm. The collected light on the output port of the Michelson Interferometer was sent to a highly sensitive photodetector, whose output was electronically filtered according to the translation stages speed. A and B scans were obtained for several samples. Samples of extracted molar human teeth (available at the University bank tooth) were sectioned and restored with amalgam and composite resin, and failure gaps were purposely introduced in selected regions of the tooth enamel using 50μm thick acetate sheets. Figure 1 shows a summary of the A and B scan results, displaying the interferometric backscattered amplitude as a function of axial position and lateral displacement along the gap. Left figure shows a trace where there is no gap purposely left, and the enamel-restoration interface is seen, while right figure shows a purposely left failure gap using the 50μm acetate sheet on an amalgam restoration. The gap is clearly detected, and is wider than the acetate sheet due to natural imperfections in placing the acetate. From our data, a 2D plot has been constructed. The results were compared to radiographic images, showing the potential of the technique for detection of earlier caries, since X-Ray can not show the gap failure, only depicting the restored region. OCT has the advantage of showing the restored region as well as the gap, if existing, localizing precisely its position.

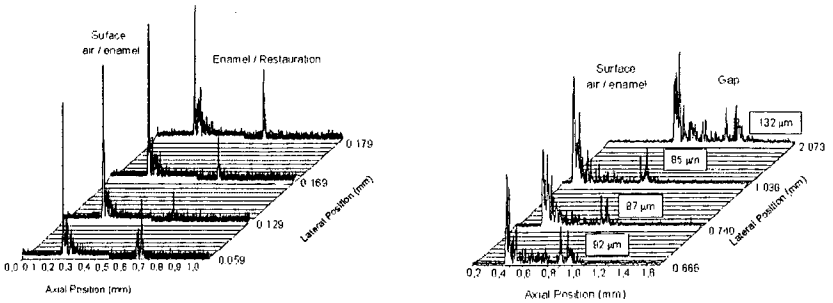

Figure 1 – (left) A and B scans of restoration/enamel interface; (right) A and B scans of restored cavity with a purposely introduced gap.

[1] D. Huang, *et al.*, "Optical coherence tomography" Science **254**, 1178 (1991).
[2] B.W. Colston, *et al.*, "Imaging of hard- and soft-tissue structure in the oral cavity by optical coherence tomography" Applied Optics **37**, 3582 (1998); B.W. Colston, *et al.*, "Dental OCT" Optics Express **3**, 230, 2 (1998); F.I. Feldchtein, *et al*, "*In vivo* OCT imaging of hard and soft tissue of the oral cavity" Optics Express **3**, 239 (1998).

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