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Material defects investigation in fixed partial dentures using optical coherence tomography method

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INTRODUCTION: In odontology, a series of reports first appeared in 1998, with images of both hard and soft oral tissues. This led to several diagnostics of bucal diseases, including periodontal, early carries, among others. Another area in dentistry where OCT can have important findings is in dental restoration imaging. Wang et al. and Fried et al. explored polarization-sensitive OCT to identify dental tissue/restoration interfaces. Up to this date, there is no quantitative method able to perform in vitro or in vivo analysis of dental restoration, particularly from the clinical point of view. Visual inspection and x-ray imaging are not precise enough to diagnose small gaps that result from bad restoration procedures.

METHODS: In this work we used two different OCT systems that were assembled by the Applied Optics Group of the University of Kent. The optical configurations are similar to those presented before in [1,2] using two single mode directional couplers with a superluminiscent diode as the source. Unlike conventional A-scan based time-domain OCT [3] , en-face OCT systems[4] were used which can deliver B-scans and C-scans from en-face (or T-scan) reflectivity profiles. This is similar to the procedure used in any confocal microscope, where the fast scanning is en-face and the depth scanning (focus change rather than a change in the reference arm length in the case of an OCT) is much slower (at the frame rate). Sequential and rapid switching between the en-face regime and the cross-section regime, specific for the en-face OCT systems developed by us, represents a significant advantage in the non-invasive examination of prostheses. The frame grabber is controlled by signals from the generators driving the X-scanner and the Y-scanner. One galvo is driven with a ramp at 500 Hz and the other galvo-scanner with a ramp at 2 Hz. Systems operating at 670 nm, 850 and 1300 nm were used. Both systems have typical working distances of 2 to 3 cm and depth resolutions of 18 to 20 µm (in air).

RESULTS: The gap failure in a restored tooth can be evaluated by the OCT technique, and with a system resolution of 10 µm we were able to detect gaps as small as 50 µm, but only those of a few micrometers would be experimentally measurable. Although we demonstrated only gaps that were about 0.5 mm deep, the technique can image the full enamel extension, as demonstrated in earlier work at the same wavelength as used here and verified independently in our laboratory. Therefore, this required performance criteria is satisfied by the technique. The types of restorations that could be imaged by direct and indirect means include gaps wider than the resolution of the system, which could be imaged and spatially quantified.

DISCUSSION & CONCLUSIONS: OCT has numerous advantages which justify its use in the oral cavity in comparison with conventional dental imaging. OCT can achieve the best depth resolution of all known methods (in principle 1 micron if the source exhibits a sufficiently wide spectrum) and is safe. Furthermore, the use of OCT has the advantage of showing the restored region as well as the gap, if it exists, and precisely localizing its position, as demonstrated here.

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