In vitro Examination of Secondary Caries Using Infrared Photothermal Radiometry and Modulated Luminescence

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Abstract

Dental secondary caries is defined as the carious lesion developed around existing restoration margins. Secondary caries occur at subsurface regions that are externally invisible in most cases, so the diagnosis of secondary caries often requires excavation of existing restorations for better view. For this reason the diagnosis of secondary caries is the principal cause of restoration replacement and its early failure. Many new technologies have been developed for caries detection purposes, but their sensitivity and specificity are unsatisfactory for the specific purpose of detection of secondary caries. Therefore, the development of a novel nondestructive technology to detect secondary caries has been highly necessary.

The main objective of this research work was to investigate the ability of frequency-domain photothermal radiometry (PTR) and modulated luminescence (LUM) to detect secondary caries: wall lesions and outer lesions. Changes in experimental PTR-LUM signals due to sequential demineralization on entire vertical walls (i.e. wall lesions) of sectioned tooth samples were investigated, and this experimental finding was supported by theoretical modeling and simulation. In addition, TMR analysis was conducted to measure the degrees of demineralization (as a gold

standard) occurred to each sample. Statistical analysis was conducted to find correlation coefficients between TMR results and PTR-LUM signals. More clinically relevant case of localized demineralization and remineralization on vertical walls was also investigated through experiments to see whether the PTR-LUM signals are sensitive to demineralization and remineralization of much smaller area. Moreover, another protocol was prepared to investigate how two different types of secondary caries, wall lesions and outer lesions, affect the PTR-LUM signals. Overall results of the aforementioned studies demonstrated that PTR-LUM is sensitive to progressive demineralization and remineralization on vertical walls of sectioned tooth samples, as well as to the presence of wall lesions and outer lesions developed around composite restorations.

The successful development of this technology is of intense interest to the dental industry. It will prevent unnecessary excavation of existing restorations as a screening method for secondary caries. Also, this technology will enable detection of early stages of secondary caries that can be cured by proper clinical treatments without replacing the existing restorations.