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Neural Network Classification Algorithms for the AC Impedance Method of Clinically Evaluating Dental Caries

A. Czajczynska-Waszkiewicz[b,*], *P. Los*[a], *N.B. Pitts*[a,b], *C. Longbottom*[a,b], *M. Masalski*[c], *S. Kochan*[a]

* aczajczynska@hotmail.com

[a]IDMoS Dental Systems Ltd, Dundee, [b]University of Dundee Centre for Clinical Innovations, UK; [c]Technical University of Wroclaw, Poland

The aim of this study was to explore the application of fitting methods and classification algorithms based on neural network applications to caries detection by the ac impedance method. 51 extracted human teeth, with lesions representing a range of different stages in the development of the caries process were studied. The teeth were stored in thymolised physiological saline. During measurement, teeth were in correct anatomical relationships and were kept moist. Measurements were made at room temperature in vitro using a prototype caries detection device (IDMoS Dental Systems Ltd., UK). More than 600 ac impedance curves were measured and fitted to determine values for both the Rb (dc resistivity) and ϕ (phase angle) parameters. Rb and ϕ values were then used to build a neural network to enable the evaluation of caries stages in a clinically meaningful way. Following impedance measurements, teeth were studied using the microCT method to obtain validating information as to the true status of each tooth surface. The Rb values were classified initially for sound surfaces, incipient lesions and cavitated lesions. Clinical classification of R_b and ϕ values was then carried out using a Learning Vector Quantization neural network. The network consists of neurons that are represented by a vector of parameters. In this experiment each neuron is a triplet (Rb, ϕ, class). The neural network classifies the measurement result as a class of a neuron on the basis of the lowest distance from a certain neuron defining a clinical class. It is concluded that, as the values produced to date with the network gave improved caries detection, the application of such neural networks in the clinical evaluation of caries by the ac impedance method should be explored further.

Supported by IDMoS.

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Statistical Analysis of the Effectiveness of AC Impedance in Detection of Early Caries in vitro

N.B. Pitts[a,b,*], *P. Los*[a], *C. Longbottom*[a,b], *A. Czajczynska-Waszkiewicz*[b], *S. Kochan*[a]

* n.b.pitts@chs.dundee.ac.uk

[a]IDMoS Dental Systems Ltd, Dundee, [b]University of Dundee Centre for Clinical Innovations, Dundee, UK

The aim of study was to develop a new method of ac impedance spectra analysis to improve still further the resolution of the measurements of the early caries lesion. Whereas in most previous studies on electrical properties of teeth the values of the resistance parameters were used directly for clinical applications, in the present work capacitance parameters were also analysed to help differentiate between the different stages of caries. The measurements were carried out using a small radius microelectrode in a simulation of oral cavity conditions. Radiographic, photographic and SEM methods were used to evaluate the true caries status of each of 20 unrestored human premolar teeth. The smooth surfaces of the samples were assigned to one of two groups according to their macroscopic condition by the consensus of four examiners by visual inspection: S (sound) and L (lesion), if a white or brown spot carious lesion. Student's t-tests for the differences between the means of capacitance parameters T and ϕ at different variances were used to estimate the absence of differences between the means. The level of confidence was 0.05. The differences between means for the couples of data SB (sound buccal)-L (lesion) (T 0.0044 and ϕ 0.0000), and SD (sound distal)-L (lesion) (T 0.0000 and ϕ 0.0000) were lower than the assumed level of confidence and, in these experimental conditions, it was statistically impossible to make an error in caries detection. Consequently, 100% sensitivity and specificity of early caries detection on smooth surfaces are reported in vitro by using a combination of resistance and capacitance parameters.

Supported by IDMoS.

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Detection of Incipient Caries with Dental Photothermal Radiometry: Experiments and Theoretical Modeling

A. Matvienko[a], *R.J. Jeon*[a], *A. Mandelis*[a], *S.H. Abrams*[b,*], *G. Kulkarni*[c]

* dr.abrams4cell@sympatico.ca

[a]Center for Advanced Diffusion Wave Technologies, Department of Mechanical and Industrial Engineering, [b]Four Cell Consulting, Toronto, [c]Faculty of Dentistry, University of Toronto, Canada

Dental enamel demineralization is very difficult to detect or monitor with either x-rays or visual examination. In this study, Dental Photothermal Radiomety (DPTR), a biothermophotonic approach developed at the University of Toronto, was applied to safe, non-destructive detection of early enamel demineralization. Mesial and distal enamel surfaces of human molars were sequentially etched for up to 20 s with 37% phosphoric acid gel. A semiconductor laser (659 nm, 80 mW) was the source of the PTR signal. The laser beam was focused on the sample to a spot size 121 $\pm$ 8 μm. Modulated laser light in the visible range generated infrared blackbody radiation from the tooth surface upon absorption and nonradiative energy conversion. The infrared flux emitted by the etched region was focused by two off-axis paraboloidal mirrors and monitored with an infrared detector twice: before and after etching. The samples were mounted on LEGO bricks and controlled by precision micro-stages. The output signal was acquired automatically using developed instrument control software, so no operator input influenced the results. Based on the averaged values for 4 samples, 5 s etching reduced the PTR amplitude by 16.5% and PTR phase by 4.3%, 10 s etching by 33.8 and 11.3%, and 20 s etching by 40% and 12.8% respectively. The results showed that DPTR can detect early mineral loss even after 5 s of etching; dental bitewing radiographs did not indicate any changes on these surfaces even after

1 min etching. A coupled diffuse-photon-density-wave and thermal-wave theoretical model was developed to describe the biothermophotonic phenomena in a two-layer turbid medium. As a result, the DPTR technique was shown to be a powerful tool for the detection of early demineralization of the enamel surface. The next stage is to apply the technique to detection of incipient artificial caries lesions.

Supported by Stephen H. Abrams (Four Cell Consulting, Toronto, Canada).

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Interproximal Caries Detection Using Frequency-Domain Infrared Photothermal Radiometry

R.J. Jeon[a,*], *A. Matvienko*[a], *A. Mandelis*[a], *S.H. Abrams*[b], *B.T. Amaechi*[c], *Gajanan Kulkarni*[d]

* raymondj@mie.utoronto.ca
[a]Center for Advanced Diffusion Wave Technologies, Department of Mechanical and Industrial Engineering, University of Toronto, [b]Four Cell Consulting, Toronto, Canada, [c]Department of Community Dentistry, University of Texas, San Antonio, USA; [d]Faculty of Dentistry, University of Toronto, Canada

Frequency-domain photothermal radiometry (FD-PTR, PTR) has been used with 670 nm (450 mW) and 659 nm (80 mW) semiconductor lasers to detect mechanical and chemical defects in the interproximal area of extracted human teeth. 14 pairs of teeth were mounted on LEGO bricks which allowed the teeth to be separated and remounted precisely. All sample pairs were controlled by precision micro-stages and data were acquired and stored by a computer, so the measurement system was free from operator bias. Preliminary tests on mechanical holes generated by ¼-round dental burs and 37% phosphoric acid etching (20 s) on the interproximal contact spots showed apparent differences in the PTR signal. Interproximal caries was simulated on areas 2~3 mm diameter, located at the contact point, by two methods: (1) a partially saturated acidic buffer system [ten Cate and Dujjsters: Caries Res 1983;17: 193–199]; (2) an acidified gel system [Amaechi et al.: Arch Oral Biol 1998;43:619–628] to demineralize the enamel, followed by the remineralization solution which is the same as solution (1) without acetic acid and at neutral pH. Each sample pair was examined with PTR before and after treatment at times from 6 h to 30 days. Bitewing radiographs showed no sign of lesion even for samples treated for 30 days. After completing all the experiments, micro-CT, TMR and SEM analyses were performed to compare and correlate the PTR signals to depth of lesions and density changes. PTR amplitude increased by more than 300% in 80-hour acidic buffer lesions and 30% in 3-day gel lesions. PTR phase also changed by 5~13 degrees for both buffer and gel. Therefore, PTR has been shown to have the potential to be a reliable tool for detection of early interproximal carious lesions. Modulated luminescence showed lower sensitivity to these interproximal lesions than PTR.

Supported by Stephen H. Abrams (Four Cell Consulting, Toronto, Canada).

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CD14 Gene Polymorphism in Relation to Caries

J.J. de Soet[a,*], *L. van Driel*[a], *J. Pleijster*[c], *S.A. Morré*[c], *M.C.M. van Gemert-Schriks*[b]

* jj.desoet@vumc.nl
Departments of [a]Oral Microbiology and [b]Pediatric Dentistry, ACTA, Vrije Universiteit and Universiteit van Amsterdam; [c]Laboratory of Immunogenetics, VUMC, Amsterdam, The Netherlands

In multibacterial diseases, such as caries and periodontitis, presentation of antigens to the immune system is essential for an adequate host defence. Dental caries is a process in which cytokine involvement is not likely since it is merely a chemical process. In an advanced dentinal lesion, however, bacterial products such as lipoteichoic acid may migrate to the pulp. These are recognized by CD14 and toll-like receptors resulting in a NF-κB-based inflammatory response. This will induce the production of cytokines which in turn recruits inflammatory cells, thereby evoking a local inflammation. We hypothesised that individuals who produce more CD14 due to a genetic variation in the *CD14*-260 promoter region of the gene would produce abscesses or fistulae more frequently than controls in response to a bacterial infection of the dentin. To test our hypothesis, we clinically examined 380 6-year-old Surinam children, as a part of a longitudinal study, for the presence of a T-allele at position *CD14*-260, causing an up-regulation in CD14 production, and correlated this with the presence of abscesses or fistulae one year after the initial measurement. The T-allele polymorphism was determined from DNA isolated from blood cells using a PCR based technique. The *CD14*-260T genotype was found in 45% of the population. From the individuals with dmft >7 and the presence of abscesses or fistulae, 78% carried the *CD14*-260T-allele, while in the no-abscess group 41% carried the T-allele (Fisher exact test p = 0.02, OR 3.8, 95% CI 1.1,11.9). From these results we conclude that carriers of a *CD14*-260T allele are more susceptible to inflammation as a result of a carious lesion.

Session 8
Microbiology/Dental Plaque

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Identification and Quantification of Streptococci in Dental Biofilms in situ

I. Dige[a,*], *J.R. Nyengaard*[b], *H. Nilsson*[c], *M. Kilian*[a], *B. Nyvad*[a]

* idige@odont.au.dk
[a]School of Dentistry, [b]Stereological Reseach Laboratory, [c]Institute of Physiology and Biophysics, [d]Institute of Medical Microbiology and Immunology, Faculty of Health Sciences, University of Århus, Denmark

New methodologies such as confocal laser scanning microscopy (CLSM) in combination with fluorescent in situ hybridization (FISH) may help increase our knowledge about biofilm formation.