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Evaluation of the Cariogram for root caries prediction

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ABSTRACT

Objectives: The aim of this study was to evaluate complete and reduced Cariogram models in predicting root caries risk in independently living older adults by comparing the caries risk assessment of the programme to observed root caries increment over a two-year period.

Methods: A prospective study recording root caries incidence was conducted on 334 dentate older adults. Data were collected on participant's medical history, fluoride exposure, and diet. Saliva samples were collected to measure salivary flow rate, buffer capacity and bacterial counts. Clinical examination was completed to record decayed, missing and filled teeth (DMFT) and also exposed, filled and decayed root surfaces (RDFS). This was repeated after 12 and 24 months. Scores were entered into the Cariogram and baseline risk category was recorded. Reduced Cariogram models were generated by omitting individual salivary variables and all salivary variables. The performance of the complete and reduced Cariogram models in predicting root caries incidence were evaluated by receiver operating characteristic (ROC) analysis.

Results: 280 participants were examined at two year follow up. 55.6% of those in the highest risk group developed new caries compared to 3.8% in the lowest risk group. The mean root caries increment in the highest risk group was 2.00 (SD 3.20) compared to 0.04 (SD 0.20) in the lowest risk group. The area under the ROC curve for the complete Cariogram model was 0.77 (95% CI 0.70–0.83) indicating a fair performance in predicting root caries. Omitting individual or all salivary variables did not significantly alter the predictive ability of the Cariogram.

Conclusion: Within the limitations of this study, the Cariogram was clinically useful in identifying individuals with a high risk of developing root caries.

Clinical significance: Identification of a caries risk assessment tool which could reliably select high-risk individuals for root caries prevention strategies would maximise the cost effectiveness of professionally delivered prevention measures.

1. Introduction

It has been reported that approximately one third of the older adult population bears most of the root caries burden [1,2]. Root caries is a preventable disease. Targeted root caries prevention or remineralisation measures delivered by oral healthcare professionals have been shown to be more effective than self-administered measures such as fluoridated dentifrices [3]. Identification of a caries risk assessment tool which could reliably select high-risk individuals for root caries prevention strategies would maximise the cost effectiveness of professionally delivered prevention measures.

The Cariogram, an interactive computer-based caries risk assessment programme, was developed in Malmö, Sweden, initially for use as an educational aid [4]. This programme has since been shown to be

capable of predicting caries increment more accurately than any single-factor model and its validity has been evaluated in more prospective cohort studies than any other caries risk assessment tool [5]. The Cariogram programme presents a caries risk assessment for an individual according to a weighted evaluation of nine caries-related factors. The original formula and the weight assigned to each factor were derived from large sets of population data and the algorithm has remained unchanged since its inception in 1997. The model has been evaluated in a wide range of patient groups from pre-schoolers to the elderly [2,6]. However, no measurements related to prediction model performance (e.g. sensitivity, specificity) of the Cariogram for the purpose of root caries prediction have been explored to date. Translation of the use of the Cariogram into general practice could also be impaired by the inclusion of salivary tests which require access to a

chairside incubator and also 48 h for incubation. These tests also add a significant cost to the use of the Cariogram for caries risk assessment. A previous study investigated the predictive ability of a reduced Cariogram, without the inclusion of any salivary variables [7]. This study found that omission of the salivary parameters increased the sensitivity of the model, but at the expense of the specificity.

The aim of this study was to evaluate complete and reduced Cariogram models in predicting root caries risk in independently living older adults by comparing the caries risk assessment of the programme to actual root caries increment over a two-year period.

2. Materials and methods

2.1. Study design

The protocol for this longitudinal study received ethical approval by the Clinical Ethics Committee of the Cork Teaching Hospitals (ECM 4 Y 06/12/11). The study was conducted in compliance with the principles of the Declaration of Helsinki and the STROBE guidelines [8]. Written informed consent was obtained from each participant. Eighty-five of the individuals whose data are included in this report were also enrolled in a randomised controlled clinical trial comparing restorative materials in the operative treatment of root caries [9].

2.2. Recruitment

Adults aged over 65 years of age with some remaining natural dentition were invited to attend Cork University Dental School and Hospital for a free dental examination. Advertisements were placed in local shopping centres, community centres and the local press over a period of three months. Telephone contact details of the study co-ordinator were provided and patients were allocated appointments provided they were the appropriate age, and confirmed they had some of their natural dentition remaining. All of the patients recruited to the study were independently living older adults. No financial rewards were offered to patients. Recruitment commenced in October 2012 and was completed in November 2013.

2.3. Inclusion and exclusion criteria

The inclusion criteria for entering this study were:

- Aged 65 or over
- Present a minimum of one natural tooth
- Living independently in the community
- Have sufficient cognitive ability to understand consent procedures

The exclusion criteria for this study were:

- Those living in nursing home facilities
- Individuals who had taken antibiotics in the previous month (as this may alter the oral microflora)

2.4. Data collection and oral examination

Each participant completed a questionnaire which recorded their medical history, medications, fluoride exposure and diet information. Patients were advised to avoid eating, drinking, smoking, chewing gum, tooth brushing, or mouthwashes for one hour prior to their appointment. Saliva was collected over a period of five minutes following one minute of stimulation by having the participant chew a paraffin pellet. Xerostomia was defined as a stimulated saliva flow rate of < 0.7 ml saliva/min.

The CRT® Caries Risk Test (Ivoclar-Vivadent, Schaan, Liechtenstein) was used to record the salivary buffer capacity and counts of mutans streptococci (MS) and lactobacilli (LB). The buffer capacity of stimulated saliva was determined using CRT Buffer® (Ivoclar-Vivadent). The test field of the buffer strip was wetted entirely with stimulated saliva using a pipette. After 5 min of reaction, a coloured chart provided by the manufacturer was used to record the buffer capacity as low, medium or high. The MS and LB counts per millilitre saliva were recorded using CRT Bacteria® (Ivoclar-Vivadent). The agar surfaces were wetted with stimulated saliva and incubated at 37 °C (99 °F) for 48 h. The MS and LB counts were scored in two categories: $< 10^5$ or $\geq 10^5$ CFU/ml saliva.

A single trained examiner performed a baseline oral exam in a standard dental operatory equipped with a dental light and air-water syringe. Plaque scores were recorded using the mucosal plaque score (MPS) index [10]. Teeth were cleaned with an ultrasonic scaler, rubber cup and prophy paste and were washed and dried prior to caries detection. Decayed, missing and filled teeth (DMFT) were recorded. Root surfaces were anatomically defined as those surfaces apical to the cementoenamel junction (CEJ). The root caries classification system used was a modification of the International Caries Detection and Assessment System (ICDAS II) [11] as described in a previous publication [12]. New root caries (for the purposes of statistical analysis) was defined as an active, cavitated (≥ 0.5 mm lesion) lesion, either wholly or partly on the root surface, which offered no resistance to a ball-ended probe.

Participants were invited for review 12 and 24 months after their baseline examination. At this time one of two calibrated examiners repeated the clinical examination procedure outlined above. Root caries increment for each adult over the two-year period was calculated as the number of root surfaces which had developed a new active, cavitated lesion in that time. A new lesion on a previously restored root surface was categorised in the same manner as a new lesion on a previously sound root surface.

2.5. Data entry into the Cariogram

The Cariogram software was downloaded in English from https://www.mah.se/fakulteter-och-omraden/Odontologiska-fakulteten/Avdelning-och-kansli/Cariologi/Cariogram. The settings for "country/area" and "group" were kept at standard. The range for "normal" caries experience was calculated as the mean DMFT score (22.4) reported for adults over 65 in the UK Adult Oral Health Survey 2009 +/− one standard deviation (5.3) [13]. The clinical judgement category was set at 1 to nullify this factor. Therefore the range for normal caries experience used was a DMFT score of between 17 and 28. More detail on the scoring method in each category is available from the Cariogram manual (Internet version 2) [14]. Participants were divided into five groups at baseline according to the assessed chance of avoiding caries, from the highest risk group, with a 0–20% chance of avoiding caries, to the group with the lowest predicted risk for caries, i.e. 81–100% chance of avoiding caries over the two-year follow-up. This procedure was then repeated to create the reduced Cariogram models; one model with mutans streptococci removed, one with saliva buffer capacity removed, one with saliva secretion rate removed, and finally one with all of the aforementioned salivary variables removed. Both patients and examiners were blinded to the patient's initial caries risk assessment.

2.6. Statistical analyses

Data from case report forms were entered into SPSS (version 22; SPSS, Inc., an IBM Company, Chicago, IL, USA) software. Fifteen participants were re-examined one week after the initial exam. Intra-examiner reproducibility at root surface level was measured by the mean kappa statistic which was 0.95 for root caries detection at the active cavitated level (as described above). Inter-examiner reliability between the two reviewing examiners was 0.94. The performances of