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Short communication

QLF is not readily suitable for *in vivo* denture plaque assessment

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ABSTRACT

Objectives: Current methods available for denture plaque assessment utilise visual and planimetric techniques. This paper evaluates the use of the Quantitative Light-induced Fluorescence system (QLF™) in image capture of denture plaque and the suitability of these images for planimetric plaque measurement. It is proposed that fluorescence imaging could provide a valuable and sensitive standardising method for plaque assessment in clinical trials for denture cleansing products and denture hygiene. Indeed, the detection of red fluorescent plaque using the QLF system is indicative of black-pigmented obligate anaerobes and mature plaque.

Methods: The QLF system was evaluated in a clinical study for use in denture plaque assessment in comparison to white light based image capture.

Results: Despite appearing as a promising system for denture plaque quantification, this study revealed numerous problems associated with the QLF system including small focal depth, thus large numbers of images and processing time were required. In addition, differential fluorescence of acrylic made images unsuitable for plaque quantification.

Conclusion: QLF is unsuitable for *in vivo* denture plaque assessment. However, the visualisation of red autofluorescence, indicating mature plaque, remains an important clinical use of QLF for denture hygiene assessment.

1. Introduction

Fluorescent detection of dental and denture plaque is a non-contact, non-destructive technique that has received increased attention due to its high sensitivity and specificity.[1] Fluorescent detection systems employ excitation sources ranging from red and blue (UV) lasers[2,3] to xenon lamps with filters[4,5] and LEDs,[1] and utilise natural fluorescence in the substrate or fluorescence via staining.

The Quantitative Light-induced Fluorescence (QLF™) imaging system (Inspektor Research Systems, BV) is a novel dental diagnostic tool that has been used for *in vivo* and *in vitro* quantitative assessment of dental caries, tooth whitening, bacterial activity, calculus, staining, and dental plaque.[6–8] The

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technique is based on the autofluorescence of teeth, which when illuminated with visible blue light (405 nm), emit in the green part of the spectrum.

Advantages of QLF include objectivity, high sensitivity, reliability, repeatability, reproducibility and accuracy. Unlike traditional plaque scoring methods, QLF has the potential to allow irradiation of 'undisturbed'/undisclosed plaque, which together with video repositioning software makes it ideal for longitudinal studies. Three clearly separated image components are required for planimetric analysis; tooth without plaque, tooth with plaque and surrounding structures.[9] Pixel counts of plaque make it possible to obtain a measurement of very high resolution in comparison to plaque indices scores.[8] Most clinical plaque studies involve a minimum of 20 subjects per treatment group.[10] QLF imaging may decrease the number of subjects required due to increased sensitivity of the plaque measurement.

In dental materials for prosthetic teeth, the most critical acceptance criterion is aesthetics, influenced by colour translucency, gloss, and fluorescence (bright teeth). A good denture tooth reflects and refracts light arriving from different directions and fluoresces under UV light, mimicking natural living teeth.

To the authors' knowledge, the QLF system and software has not been applied to dentures. It could provide a valuable and sensitive standardising method for plaque assessment in clinical trials for denture cleansing products and denture hygiene. Indeed, the detection of red fluorescent plaque on dentures using the QLF system is indicative of black pigmented obligate anaerobes and mature plaque,[11] whereas both primary and some secondary plaque colonisers have been shown to fluoresce green.[12] Recently the authors have reviewed the pathogenic aspects of denture plaque and the importance of adequate denture hygiene to control associated oral and systemic diseases.[13] Current methods available for denture plaque assessment utilise visual and planimetric techniques,[14] thus this paper evaluates the use of fluorescence in image capture of denture plaque and the suitability of these images for planimetric plaque measurement.

2. Aims

The aim of this study was to evaluate the use of the QLF system for *in vivo* denture plaque imaging and assessment.

3. Methods

In a clinical study the use of fluorescent light with the QLF system in comparison to white light based image capture[14] was assessed. The study was conducted in accordance with the declaration of Helsinki (1964) and subsequent amendments. Ethical approval was obtained prior to the start of the study from the appropriate Local Research Ethical Committee. All volunteers were provided with information sheets, and signed, witnessed informed consent was obtained. Volunteers were advised of their right to withdraw from the study at any time.

Thirty-five outpatients from a student clinic at a local dental hospital seen for consultation relating to prosthodontic problems took part in this study. Forty complete and partial removable PMMA prostheses including 28 complete maxillary dentures, six complete mandibular dentures and six partial maxillary dentures were assessed. The study design was prospective and non-interventional. Dentures were imaged with a digital camera (Nikon D100) fixed to a copy stand (approximately 15 cm away from the denture) under white light and subsequently with the QLF^{TM}CLIN system (Inspektor Research Systems) both before and after disclosing plaque. Denture plaque was disclosed using PlaqueFinder (Pro-Dentec, Rota-Dent, Cambridge, UK), which combines two dyes, erythrosine (E127, red) and E133 blue to differentiate older (blue) and newer (red) plaque as a standard method for plaque visualisation. Repeat imaging enabled direct comparison of image quality/clarity/usefulness between the methods for subsequent analysis and also to determine if undisclosed plaque on dentures can be quantified by QLF for longitudinal studies as. Dentures were cleaned in 0.1% (1000 ppm) hypochlorite with a soft toothbrush, rinsed and returned to the subject.

Six white-light digital images were captured for each denture, comprising left and right sides of each of the fitting surface, buccal teeth surfaces and lingual teeth surfaces. The QLF^{TM}CLIN system was used to capture several images representing all denture surfaces (12 images per denture, with a maximum of two teeth in focus per image). QLF images of dentures were assessed for fluorescence intensity of the denture surfaces. Images with and without disclosed plaque were assessed for contrast of plaque against the denture surface, using image-processing software (Adobe Photoshop v7) to select the plaque and denture surface area.

4. Results

Detection of fluorescent plaque was dependent on the autofluorescence of the denture teeth. The pink PMMA denture acrylic base did not fluoresce in any of the dentures screened. Individual denture teeth showed wide variation in fluorescence; some were uniform in fluorescence radiance (unlike natural teeth), and others were entirely non-fluorescent. Fluorescence was dull or bright green. For 13 dentures, all teeth fluoresced, and in seven dentures only the incisors fluoresced. The remaining dentures (20/40) had very dull or non-fluorescent teeth, which were unsuitable for imaging. Red fluorescence in plaque was detected on fluorescent and non-fluorescent acrylic prior to disclosure. Disclosure itself reduced the fluorescence of plaque to some extent. Green fluorescence in plaque was imaged on non-fluorescing teeth before disclosure (Fig. 1a) but was masked by disclosing the plaque (Fig. 1b). On fluorescent teeth no fluorescent green plaque was visible (Fig. 1c), but after disclosing plaque showed up as dark patches on the green background of the tooth (Fig. 1d). Red fluorescent plaque was visible on fluorescent teeth (Fig. 1c) and disclosing revealed the extent of plaque coverage, although the red colour was masked (Fig. 1d). There was no observed correlation between the presence of red fluorescent plaque and total disclosed plaque area. Disclosing