ORIGINAL ARTICLE

A Kasaj
I Moschos
B Röhrig
B Willershausen

The effectiveness of a novel optical probe in subgingival calculus detection

Authors' affiliations:
Adrian Kasaj, Ioannis Moschos, Brita Willershausen, Department of Operative Dentistry and Periodontology, Johannes Gutenberg-University Mainz, Mainz, Germany
Bernd Röhrig, Institute of Medical Biostatistics, Epidemiology and Informatics, Johannes Gutenberg-University, Mainz, Germany

Correspondence to:
Adrian Kasaj
Department of Operative Dentistry and Periodontology
Johannes Gutenberg-University Mainz
Augustusplatz 2
55131 Mainz
Germany
Tel.: +49 6131 173064
Fax: +49 6131 173406
E-mail: kasaj@gmx.de

Dates:
Accepted 26 August 2007

To cite this article:
Int J Dent Hygiene **6**, 2008; 143–147
Kasaj A, Moschos I, Röhrig B, Willershausen B. The effectiveness of a novel optical probe in subgingival calculus detection.

Abstract: *Objectives:* The aim of the present study was to evaluate the effectiveness of a novel optical calculus detection system under *in vivo* conditions. *Methods:* One hundred and seventy-six tooth surfaces from 44 adult teeth that were indicated for extraction were selected for the present study. The patients were randomly assigned to one of the two experimental groups. In group A (n = 96), clinical presence or absence of subgingival calculus deposits was determined using the light-emitting diode-based optical probe (OP). In group B (n = 80), the subgingival deposits were first recorded with the OP followed by root surface debridement until no subgingival deposits could be detected by the device. Teeth were then extracted and examined under a stereomicroscope by two trained dentists (DENT 1, DENT 2) and a dental student. Results were compared with the measurements of the OP and direct visual control. *Results:* In group A, post-extraction results revealed 89% and 90% agreement with the positive and negative OPs detection. In group B, 17% of the surfaces demonstrated even after subgingival debridement and control with the detecting device still calcified deposits in the microscopic evaluation. The highest inter-examiner agreements were observed between DENT 1 and DENT 2. *Conclusion:* It was shown that the optical detection system identifies subgingival calculus with a high efficacy and therefore, may be a support for the operator to determine the endpoint of root surface instrumentation.

Key words: calculus detection; DetecTar; root surface; scaling and root planing; subgingival debridement

Introduction

The effectiveness of non-surgical periodontal therapy to reduce gingival inflammation, to decrease probing depths and to arrest progression of periodontal disease has been shown in numerous clinical trials (1–3). For this purpose, different types of instruments (e.g. hand instruments and machine-driven instruments) have been developed to perform subgingival debridement (4). However, it has been observed that complete subgingival calculus removal and root planing without extensively removing the underlying cementum might be difficult and is often inadequately performed (5). A lack of visual control (VC) represents one of the main disadvantages of subgingival debridement. Currently, the thoroughness of subgingival debridement is determined by the degree of smoothness and hardness of the root surface. The clinician traditionally evaluates the endpoint of root surface instrumentation by the use of an explorer, periodontal probe or sharp curette and has to rely on his tactile sense to judge the morphology of the tooth surface. However, the use of explorer tips failed to differentiate between burnished residual calculus and cementum and also failed to be an accurate method for subgingival calculus detection (6). Several studies have demonstrated that considerable amounts of calculus were to be retained over areas judged clinically smooth (7–9). Furthermore, it has been reported that a complete removal of plaque and calculus was more difficult to achieve in deep pockets than in shallow pockets, whereas the tooth type did not influence the results obtained (8). Residual calculus has also been found frequently after non-surgical debridement at the cemento-enamel junction, in grooves, concavities, or furcation areas (10). Therefore, different detection systems have been developed to help clinicians to diagnose the presence of subgingival calculus in those areas of the periodontal pocket that cannot be controlled visually. Current detection systems are based on measurements of resonance vibrations of ultrasonic treatment or autofluorescence induced by laser irritation (11, 12). Recently, a novel calculus detection system (DetecTar; Ultradent, Salt Lake City, UT, USA) employing spectro-optical technology has been suggested as a potential aid in detecting subgingival calculus. The diagnostic optical probe (OP) is designed to be both specific and sensitive for calculus detection.

The purpose of the present study was to determine the effectiveness of subgingival calculus detection using this novel measurement device, and to compare its detection with the actual presence of calculus found on the teeth following extraction.

Materials and methods

Patient selection

A total of eight patients, six males and two females, 39–60 years of age, with advanced periodontal disease, were selected for the study. Prior to any treatment procedures, patients were informed about possible treatment alternatives as to the character and purpose of the study and were required to sign an informed consent. The study was in accordance with the Helsinki Declaration of 1975, as revised in 1983. Patients with systemic diseases and a history of antibiotic use or any form of periodontal treatment in the previous 6 months were not included in the present study.

Four to 16 hopeless teeth within each patient were condemned for extraction because of periodontal or prosthetic reasons, like caries, mobility and extrusion. A total of 44 teeth were evaluated on the mesial, distal, facial and lingual surfaces and 176 surfaces were provided for evaluation.

Instrument

The measurements were carried out by using a light-emitting diode (LED)-based OP (DetecTar; Ultradent). This device is based on the ability to identify the characteristic optical signal of subgingival calculus. Red LED radiation reflected from the illuminated root surface is sensed by an optical fibre and converted into an electrical signal for analysis. A computer-processed algorithm determines whether the probe is in contact with dental calculus.

Methods of measurements

The patients were randomly assigned to one of the two experimental groups. The clinical presence or absence of subgingival calculus deposits was always recorded by the same calibrated periodontist without any time settings. In group A (n = 96), clinical presence or absence of subgingival calculus deposits was recorded before extraction with the LED-based OP. Calculus detection was performed always with an angulation of 10–15° between the OP and the root surface in contact mode. No mechanical treatment of the root surfaces was performed in this group. In group B (n = 80), the subgingival deposits were also first recorded with the OP, however, in this group root surface debridement was performed before extraction under local anaesthesia (4% articaine with 1/200 000 epinephrine, Aventis Ultracaine D-S) using hand and/or ultrasonic instruments until no calcified deposits could be detected by the OP.

Extraction of teeth and root surface evaluation

The experimental teeth were carefully extracted in both groups, attempting not to place any surgical instrument in the pocket area (Figs 1 and 2). The extracted teeth were rinsed

Fig. 1. Extracted incisor without mechanical debridement (group A).

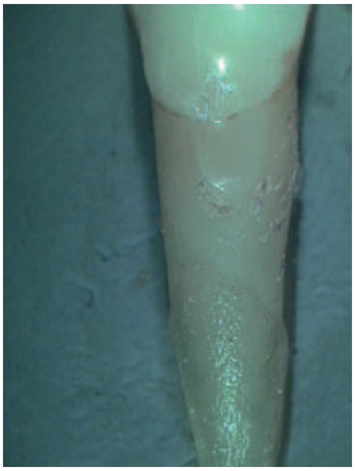

Fig. 2. Extracted incisor following mechanical debridement (group B).

with tap water and lightly brushed to remove non-adherent debris and then checked visually for the presence of calculus by an operator, who was masked as to which group the teeth had been assigned initially. Root surfaces were then examined under a Stemi 2000, stereomicroscope (Zeiss Jena, Oberkochen, Germany) at 10× magnification by two trained dentists (DENT 1, DENT 2) and a dental student (STUD) to identify the presence or absence of calculus. The presence of calculus was defined as 'any hard, discoloured, mineralized deposit attached to the root surface'. No attempt was made to quantitate the surface areas covered by calculus. The observations obtained under the stereomicroscope by DENT 1, DENT 2 and STUD were compared with the measurements of the OP and the direct VC following extraction.

Statistical analysis

The percentage of sites covered with calculus following extraction was determined and reported on both scaled and unscaled teeth. The statistical analysis was performed by using the kappa measure by Cohen and the McNemar test. Cohen's kappa statistics (κ) for the inter-examiner agreement was interpreted according to Fleiss (13): $\kappa < 0.40$, poor agreement; $\kappa = 0.40$–0.75, fair to good agreement and $\kappa > 0.75$, excellent agreement.

Results

No tooth surfaces were damaged during extraction resulting in 176 surfaces for evaluation. A total of 61.4% ($n = 27$) of the teeth were insicors, 18.2% ($n = 8$) were premolars and 20.4% ($n = 9$) were molars. Initially, 37.5% of the sites were 1–3 mm in depth, 50% were probed 4–6 mm and 12.5% exhibited probing pocket depths 7–10 mm. A total of 88.6% sites exhibited bleeding upon probing at the initial examination.

In group A, 90% of all surfaces that had been diagnosed to exhibit calculus by means of the OP could be confirmed microscopically (Fig. 3). In contrast, 10% of the sites where the clinical evaluation with the detecting device demonstrated the presence of subgingival calculus, no residual calculus could be determined microscopically. Similarly, 89% of all surfaces had no residual calculus as diagnosed previously by the DetecTar system, whereas 11% of the surfaces exhibited calculus that had not been detected by the OP. In group B, 83% of the surfaces where calculus has been detected with the OP exhibited no residual calculus in the microscopic evaluation (Fig. 4). However, 17% of the surfaces in this group demonstrated even after subgingival debridement and control with the detecting device still calcified deposits in the microscopic evaluation. In addition, 41% of the surfaces that had been diagnosed to be free of subgingival calculus in this group, presented residual calculus microscopically (Fig. 4).

The inter-examiner agreement between DENT 1 and DENT 2 was excellent exhibiting a κ-value of 0.84 (Table 1). The student examiner demonstrated only poor agreement with the two calibrated dentists with a κ-value of 0.27 and 0.28. A fair to good agreement was obtained between the two calibrated dentists and the DetecTar system with κ-values just over the 0.40 limit, whereas the student was less reliable ($\kappa = 0.1$). The inter-examiner agreement was also within the 'good' range limit between the two calibrated dentists and the VC. Similarly, a good agreement was recorded between the DetecTar system and the VC ($\kappa = 0.67$). In this comparison, 9.1% of the cases were false-positive and 1.7% of the cases were false-negative results of the used calculus detection system.

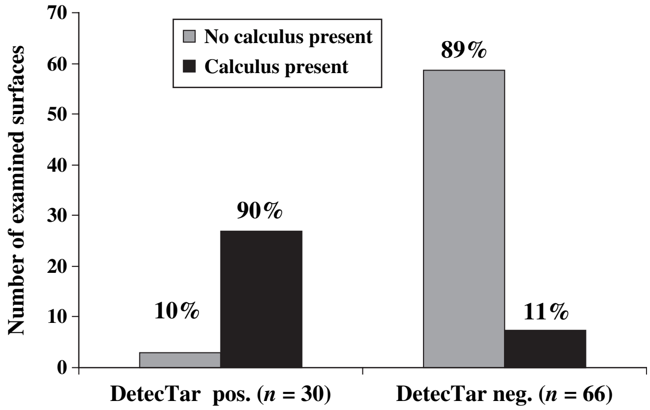

Fig. 3. Comparison of the microscopical examination of the teeth with the detection results of the optical probe (DetecTar positive, DetecTar negative; group A).

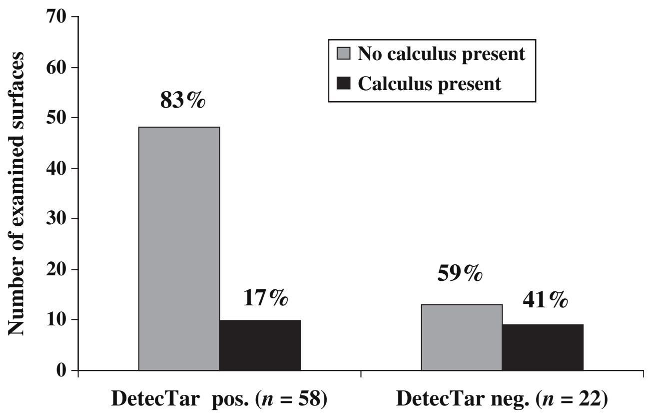

Fig. 4. Comparison of the microscopical examination of the teeth with the detection results of the optical probe (DetecTar positive, DetecTar negative) following mechanical debridement of the teeth that had been diagnosed to exhibit calculus (group B).

Table 1. **The inter-examiner agreement between the two calibrated dentists (DENT 1, DENT 2) and a dental student (STUD) in comparison with the measurements of the optical probe (OP) and the direct visual control (VC) following extraction**

	kappa (Cohen)	*P* (McNemar)	fp (%)	fn (%)
DENT 1–DENT 2	0.84	1.000	3.4	4
DENT 1–STUD	0.28	1.000	15.9	16.5
DENT 2–STUD	0.27	1.000	16.5	16.5
DENT 1–OP	0.48	<0.001	18.8	1.7
DENT 2–OP	0.44	<0.001	19.9	2.3
STUD–OP	0.103	<0.001	26.7	9.1
VC–OP	0.67	0.004	9.1	1.7
DENT 1–VC	0.69	<0.001	11.4	1.7
DENT 2–VC	0.677	<0.001	11.9	1.7
STUD–VC	0.25	0.022	21.0	10.8

fp, false-positive findings; fn, false-negative findings.

Discussion

The aim of the present study was to evaluate a novel LED-based calculus detection device under *in vivo* conditions by comparing the results of clinical calculus detection with the OP to the microscopic presence of calculus found on teeth after extraction. The results of the present study indicate that this diagnostic OP objectively detects residual calculus deposits on the root surface. With traditional assessment methods, probing and radiography, subgingival calculus detection is often difficult and not reproducible (14). There are several sources of error inherent to clinical probing, which contribute to a higher variability in the measurements. Jones *et al.* (15) pointed out that to detect all deposits every mm^2 of a subgingival pocket area would need to be explored. Thus small areas of calculus could easily be left undetected. In addition, they concluded that once a surface had been instrumented, it was not always possible to differentiate clinically among calculus, cementum and dentin. Sherman *et al.* (9) compared the clinical results after probing with an explorer with the microscopic evaluation after extraction of the teeth and demonstrated that microscopically 57.7% of all surfaces exhibited residual calculus, while clinically only 18.8% were determined to have calculus. Similarly, the present study demonstrated that following mechanical debridement no complete calculus removal could be obtained for all surfaces. The efficacy in subgingival calculus diagnosis with the LED-based OP has already been evaluated in a recent *in vitro* study (16). Thus, in all cases clinically and histologically apparent calculus on the root surface was accompanied by positive measurement values of the calculus detection system. Furthermore, a 90° angulation of the OP to the root surface and physiological saline solution as the ambient fluid demonstrated highest accuracies of the measurements. In contrast, the present study demonstrated somewhat lower accuracy in calculus detection in comparison with the *in vitro* results; however, the application of the detecting device occurred in a clinical environment without VC of the root surface. Thus, a limited access space or problematic guidance of the instrument may result in incomplete surface scanning. As a result, calculus might be in a short distance apical to the OP and be overlooked without blaming the detection method. In this context, it is not clear how the detecting device reacts on the presence of root caries or dark coloured areas on the root surface, which might explain the wrong-positive findings of the device.

The present study demonstrated excellent agreement between the two calibrated dentists. In contrast, the agreement between the calculus detection system and the VC was below the optimum, which implies a possible influence of the operator on the detection results. This could limit the application of the system in every day's periodontal practice. At this point further *in vivo* studies with a larger number of users and patients are necessary to address possible limitations of the calculus detection system. Further research is also needed to determine the possible use of the calculus detection device for patient motivation and the effect on time efficiency having an objective way to assess the endpoint of root surface instrumentation.

Conclusion

In conclusion, within the limitations of the present study, the findings demonstrate that the optical detection system identifies subgingival calculus with a high efficacy in clinical use and therefore, represents a useful adjunct for the operator in accurate detection of subgingival calculus deposits.

References

1 Morrison EC, Ramfjord Sp, Hill RW. Short-term effects of initial non-surgical periodontal treatment. *J Clin Periodontol* 1980; **7:** 199–211.
2 Badersten A, Nilveus R, Egelberg J. Effect of nonsurgical periodontal therapy. II. Severly advanced periodontitis. *J Clin Periodontol* 1981; **11:** 63–76.
3 Renvert S, Nilveus R, Dahlen G, Slots J, Egelberg J. 5-year follow up of periodontal intraosseous defects treated by root planing or flap surgery. *J Clin Periodontol* 1990; **17:** 356–363.
4 Badersten A, Nilveus R, Egelberg J. Effect of nonsurgical periodontal therapy. I. Moderately advanced periodontitis. *J Clin Periodontol* 1981; **8:** 57–72.
5 Buchanan SA, Robertson PB. Calculus removal by scaling and root planing with and without surgical access. *J Periodontol* 1987; **58:** 159–163.
6 Jones WA, O'Leary TJ. The effectiveness of *in vivo* root planing in removing bacterial endotoxin from the roots of periodontally involved teeth. *J Periodontol* 1978; **49:** 337–342.
7 Waerhaug J. Healing of the dentoepithelial junction following subgingival plaque control. II. As observed on extracted teeth. *J Periodontol* 1978; **49:** 119–134.
8 Rabbani GM, Ash MM, Caffesse RG. The effectiveness of subgingival scaling and root planing in calculus removal. *J Periodontol* 1981; **52:** 119–123.
9 Sherman PR, Hutchens LH, Jewson LG, Moriaty JM, Greco GW, McFall WT. The effectiveness of subgingival scaling and root planing. I. Clinical detection of residual calculus. *J Periodontol* 1990; **61:** 3–8.
10 Caffesse RG, Sweeney PL, Smith BA. Scaling and root planing with and without periodontal flap surgery. *J Clin Periodontol* 1986; **13:** 205–210.
11 Kocher T, Strackeljan J, Behr D. Feasibility of computer-assisted recognition of different dental hard tissues. *J Dent Res* 2000; **79:** 829–834.
12 Kurihura E, Koseki T, Gohara K, Nishihara T, Ansai T, Takehara T. Detection of subgingival calculus and dentine caries by laser fluorescence. *J Periodont Res* 2004; **39:** 59–65.
13 Fleiss JL. The measurement of interrater agreement. In: Stewart WA and Wilks SJ eds. *Statistical Methods for Rates and Proportions.* New York, John Wiley & Sons, 1981, 212–236.
14 Kepic TJ, O'Leary TJ, Kafrawy AH. Total calculus removal: an attainable objective? *J Periodontol* 1990; **61:** 16–20.
15 Jones S, Lozdan J, Boyde A. Tooth surfaces treated in situ with periodontal instruments. Scanning electron microscopic studies. *Br Dent J* 1972; **132:** 57–64.
16 Krause F, Braun A, Jepsen S, Frentzen M. Detection of subgingival calculus with a novel LED-based optical probe. *J Periodontol* 2005; **76:** 1202–1206.