Aim: We recently introduced an experimental surface detection system based on a conventional dental ultrasonic scaler. This device automatically discriminates cementum and dental calculus, which is the prerequisite for complete and thorough calculus removal. In the present study, the detection limits of this device were tested in vitro.

Material and Methods: From 50 extracted teeth, subgingival calculus was gradually removed using a Gracey curette. During this stepwise procedure, detection properties of the surface detection system were continuously monitored and systematically verified until the system stopped discriminating calculus from the root surface. By measuring the diameter, circumference and area of the smallest, yet recognizable deposit, and of the no longer recognizable deposit, the cut-off point of the discriminative capability of the detection device was determined.

Results: The cut-off points for the correct classification of residual deposits averaged on a diameter of 219 µm, an area of 21,600 µm², and a circumference of 748 µm. This means a sensitivity of 73% and a specificity of 80% in this critical area.

Conclusions: This calculus detection system was able to detect small deposits. In clinical practice, this device may support dentists in deciding whether to stop or to continue the debridement.

Study objective: The objective of subgingival instrumentation of periodontally diseased root surfaces is to remove the adhering microbial biofilm and calcified deposits. Recently, we have described an automated calculus detection system under static conditions. Clinically however, the tip of the system has to be moved over tooth surfaces. It was thus necessary to study the entire system in motion.

Methods: The detection device is based on a conventional dental piezoelectric ultrasonic handpiece with a conventional scaler insert. The impulse response of the mechanical oscillation system is analysed by a fuzzy logic-based computerized algorithm, which classifies various surfaces. The present study investigates dental surface recognition properties of the new system with the tip being moved over teeth surfaces in vitro. Following a training set of 7977 measurements (3960 calculus, 4017 cement) on 200 extracted teeth, 1363 measurements were conducted on 34 teeth unknown to the system.

Results: The surfaces cementum and calculus were correctly classified in 78% within the training set and in 81% within the set unknown, with a κ value of 0.68.
Conclusion: It was shown that this method of automatic recognition of tooth surfaces is able to distinguish between different tooth surfaces in vitro independently from tip movements.


Background: Recently, pilot studies from our laboratory have shown that dental surfaces may be discriminated by the analysis of tip oscillations of an ultrasonic instrument, which possesses computerized calculus-detection features. For the evaluation of this smart detection system, its surface recognition qualities are of crucial importance. For in vivo studies, however, it proved to be difficult to verify the subgingival detection results. Therefore, it was necessary to develop a method, which allowed a reliable validation of surface recognition results of this new device. This evaluation method is described here.

Materials and Methods: Thirty extracted human teeth with subgingival calculus were embedded with plaster in a tray. To simulate subgingival pockets, dissected mucoperiostal porcine gingiva was sutured on the teeth. The thus-constructed dentition was mounted into a phantom head. A CCD-cam was attached with an intra-oral X-ray mount to the teeth. The dentist scanned the pockets with the ultrasonic instrument, simultaneously videotaping the scanning path of the supragingival portion of the insert. At the same time, the signals of the modified ultrasound scaler were recorded. After the tooth was removed from the phantom head, the tip of the ultrasound scaler could be repositioned using the video sequences. The actual insert location on calculus or cementum was assessed and compared with the computer signals. The whole procedure was repeated a second time and the reproducibility of the evaluation method was estimated.

Results: A $\kappa$ value of 0.95 was attained for the evaluation method.

Conclusion: The present experimental design allows the in vitro repositioning of an automated dental instrument for the detection of subgingival surfaces on the tooth following an in vitro phantom-head video recording of its intra-oral scanning movements. This method will be used for the verification of in vivo results of a new ultrasound-based surface detection system.


Objectives: The aim of periodontal therapy is always the complete debridement of root surfaces with the removal of calculus and without damaging cementum. We have recently demonstrated the feasibility of a surface recognition device that discriminates dental surfaces by mathematical analysis of reflected ultrasound waves. This principle should enable the construction of calculus detecting ultrasonic device. Pre-clinical test results are presented here.
Material and Methods: An impulse generator, coupled to a conventional piezo-driven ultrasonic scaler, sends signals to the cementum via the tip of an ultrasound device. The oscillation signal reflected from the surface contains the information necessary to analyse its characteristics. In order to discriminate different surfaces, learning sets were generated from 70 extracted teeth using standardized tip angle/lateral force combinations. The complete device was then used to classify root surfaces unknown to the system.

Results: About 80% of enamel and cementum was correctly identified in vivo (sensitivity: 75%, specificity: 82%). The surface discrimination method was not influenced by the application conditions examined. A new set of 200 tests on 10 teeth was correctly recognized in 82% of the cases (sensitivity: 87%, specificity: 76%).

Conclusions: It was shown in vitro that the tooth surface recognition system is able to function correctly, independent of the lateral forces and the tip angle of the instrument.