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Advances in Calculus Detection and Removal Technologies- A Review

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ABSTRACT

The essential component of conventional periodontal therapy is the effective removal of bacterial deposits from the root surface, along with calculus deposits, in order to create a biologically compatible root surface. Subgingival root debridement currently comprises the systematic treatment of all diseased root surfaces using hand and or ultrasonic instruments, until the root surface feels smooth and clean. However, traditional tactile perception of the subgingival environment without visible access before and after treatment frequently lacks sensitivity, specificity and reproducibility, and thus may lead to the unwanted removal of cementum.Current advance technologies for calculus identification include detection-only systems (a miniaturized endoscope, a device based on light reflection and a laser that activates the tooth surface to fluoresce) as well as combined calculus-detection and calculus-removal systems. The present paper focuses on the latest advances in calculus detection technologies.

Keywords: Periodontal therapy, subgingival, calculus

INTRODUCTION

Calculus can be defined as a hard concretion that forms on the teeth or dental prostheses through calcification of bacterial plaque (Glossary of Periodontal Terms 2001)1. Depending on its location calculus can be classified as supragingival and subgingival.

Calculus is primarily composed of calcium phosphate salts covered by an unmineralized bacterial layer. It mainly consist of dicalcium phosphate dehydrate, octacalcium phosphate, hydroxyapatite and tricalcium phosphate.

Schroeder (1969)2 concluded, "Initial damage to the gingival margin is presumably due to immunological and or enzymatic effects caused by microorganisms of the plaque. This process is enhanced by the formation of supra and subgingival calculus, which provides further retention and thus promotes further plaque accumulation. Calculus itself does not cause pocket formation but in turn favours and promotes the chronicity of inflammation and thus contributes towards making it progressively worse."

Current advance technologies for calculus identification include detection-only systems (a miniaturized endoscope, a device based on light reflection and a laser that activates the tooth surface to fluoresce) as well as combined calculus-detection and calculus-removal systems.

Table 1: Automated calculus-detection technologies

Treatment goal	Technology	Device name
Calculus detection only	Fiberoptic endoscopy	Perioscopy
	Spectro-optical technology	Detectar
	Autofluorescence	Diagnodent
Calculus detection and removal	Ultrasound	Perioscan
	Laser and Autofluorescence	Keylaser3

Detection- only systems

1) Fiberoptic endoscopy based technology

The idea to modify a medical endoscope for periodontal use has, to date, been realized only in one device (Perioscopy; Perioscopy Inc; Oakland, CA, USA), which was introduced in the year 2000. It consist of fiberoptic bundle surrounded by multiple illumination fibres, a light source and irrigation system. Its miniature nature causes minimal tissue trauma. Fiberoptic system permits visualization of the subgingival root surface, tooth surface and calculus in real time on display monitor (Meissner G, Kocher T, 2011).

Fig 1: Perioscopy uses a periodontal endoscope which is inserted into the periodontal pocket, to detect calculus.

2) Spectro-optical technology
The spectro-optical approach to calculus detection uses a light emitting diode and fiberoptic technology, and is currently used by only one device, the Detec-Tar (Dentsply Professional, York, USA). Detec-Tar involves an optical fiber which recognizes the characteristic spectral signals of calculus caused by absorption, reflection and diffraction of red light (Kasaj et al 2008)[4].

3) Autofluorescence based technology
Calculus and tooth structure differ in composition. This structural difference gives a typical fluorescence to both these structures. Calculus contains various non-metals aswell as metal porphyrins and chromatophores which makes it able to emit fluorescent light when irridated with light of certain wavelength (Hibst et al 2001)[5].

Diagnodent™ (KaVo Biberach, Germany) makes use of this property of calculus to detect its presence. Calculus and teeth fluoresce at different wavelength region of 628-685nm & 477-497nm respectively. Diagnodent™ involves use of an indium gallium arsenide phosphate (InGaAsP) based Red laser diode which emits a wavelength of 655nm through an optical fibre causing fluorescence of tooth surface and calculus.

Combined detection and treatment devices
1) Ultrasonic technology
Ultrasonic calculus detection technology is based on a conventional piezo-driven ultrasonic scaler. Perioscan™ (Sirona, Germany) can differentiate between calculus and healthy root surfaces. It also has a treatment option that can be used to remove these calculus deposits immediately. This combination of detection and removal mechanism is advantageous since calculus can be removed just by switching the mode from detection to removal. The advantage lies in the fact that relocating the previously located calculus is not necessary.

Working principle of PerioscanTM Perioscan™ is an ultrasonic device that works on acoustic principles. It is similar to tapping on a glass surface with a hard substance and analysing the sound produced to find out the cracks that are present on glass. Tip of the ultrasonic insert is oscillating continuously. Different voltages are produced due to changes in oscillations depending on the hardness of the surface. Hardness of the calculus differs from the hardness of the tooth surface. This difference in hardness can be used to generate the information of the surface that is being touched by the device.

This instrument is used in two different modes. Whenever ultrasonic tip touches the tooth surface a light signal is displayed on hand-piece and actual unit. Light signal is also accompanied by an acoustic signal.

During calculus detection mode, the instrument shows a blue light when calculus is present. Once a Healthy root surface is attained, green light is displayed when the ultrasonic tip touches healthy cementum. Different power settings aid the clinician in removing tenacious calculus. The only clinical study available for this device has stated a sensitivity of 91% and specificity of 82% (Meissner et al 2008)[6].

Fig 2: PerioscanTM Fig 3: Blue light- presence of calculus

2) Laser-based technology
The benefit of laser application in non-surgical periodontal therapy is still a matter of debate among clinicians.

Keylaser3™ (KaVo Dental, NC) combines a 655nm InGaAsP diode for detection of calculus and a 2940nm Er: YAG laser for treatment. Previous versions of this system (i.e. Keylaser 1 and 2) can be used for removal of calculus only.

A scale of 0-99 is used for detection of calculus. Values exceeding 40 indicate definite presence of mineralized deposits. Er: YAG laser is activated as a certain threshold is reached. As soon as the value fall below threshold level Er: YAG laser is switched off. Studies done to assess the efficacy of this device have shown that it produces tooth surface comparable to hand and ultrasonic instruments (Folwaczny. M et al 2000)[7]. Cost factor can be a limiting aspect for using lasers for detection and treatment.

Summary
Numerous studies have been performed to assess the efficacy of hand and ultrasonic instruments in removal of calculus. Most studies indicate that some amount of calculus is always left behind irrespective of the methodology used for its removal. Percentage of residual calculus on tooth surfaces varies between 3-80% (Aoki et al 2000)8. Various studies have been carried out to assess the amount of calculus remaining on root surfaces in pockets of variable depths. The results indicate that as the pocket depth increases progressively, there is a corresponding increase in the incidence of remnant calculus (Clifford, Needleman, Chan 1999)[9].

With the knowledge that remnant calculus can lead to periodontal abscesses it becomes imperious to completely remove the calculus without causing excess root surface removal. Treatment strategies enumerated above are completely based on non-specific plaque hypothesis which targets biofilm as a whole instead of targeting individual bacteria as researchers are yet to come up with a solid tool to detect and eradicate the specific micro-organisms which are responsible for the disease in a clinical setup.

A plethora of techniques have been used to identify calculus deposits present on the root surface. Most of these techniques are capable only in identifying the calculus but not removing it. Major drawback with these techniques is that calculus has to be re identified by the instruments that are used to remove it. Hence clinicians have to rely on their ability to reproduce the results given by the detecting device, which may incorporate a manual error.

An instrument that can integrate calculus detection and removal is highly desirable as it can decrease chair-side time, lead to efficient scaling and avoid overzealous instrumentation. Such an instrument can prove to be an excellent tool in the hands of an experienced and skilled practitioner. It can also increase the patient compliance towards further dental treatment and aid in education and motivation of the patient. Further studies are warranted in order to assess the efficacy of these systems.

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