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NEWER CALCULUS DETECTION TECHNOLOGIES – AIMING AT DISEASE-FREE ENHANCED PERIODONTAL HEALTH

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ABSTRACT
The prime objective of conventional periodontal therapeutic modality is the elimination of mineralised deposits from the radicular teeth aspects by rendering it disease-free, in alignment with enhanced periodontal health. Precise detection of mineralised deposits from the radicular teeth surfaces apical to the gingival margin and adequate eradication of the biofilm along with entire mineralised calculus is the basis for overall oral health improvement of a person. These modified techniques works on the principle of identification only or its combination with elimination procedure. It helps in accurate detection as well as meticulous elimination; and should always augment traditional methods without replacing conventional detection or removal techniques in periodontal therapy. This review compiles the different advanced techniques along with their effectiveness for identification and eradication of calculus.

KEYWORDS: Calculus, periodontal therapy, advanced detection technique, technology-assisted therapy.

INTRODUCTION
Newer Calculus Detection Technologies
Deposited sub- and supragingival root calculus is microscopically wrapped by a coating of highly metabolic & activated bacterial accumulation. The primary goal of conventional mechanical debridement is efficient eradication of the formed bacterial colony & calculus from teeth superficial surfaces rendering it biologically compatible for attachment along with improvement in periodontal health status of an individual [1,2,3]. A favourable impact has been reported after absolute elimination of calcified dental plaque or calculus on the subsiding of gingival inflammation [4]. Identical healing is noted in tissues associated to teeth surfaces wrapped with minute points of burnished calcified plaque as well as among those tissues adjoining root surfaces rigorously planed and freed of any calculus deposits [5,6].
These calcified plaque deposits are permeable absorbent particles which absorbs different types of noxious by-products, thus possesses noteworthy endotoxin amounts that leads to tissue destruction [7]. These deleterious products are found in abundance on periodontally-diseased radicular aspects of teeth [8,9,10]. Thus it is concluded that the excessive eradication of cementum is unnecessary. Radicular teeth surfaces must be cautiously inspected for deposits of dental calculus & biofilm followed by judicious mechanical debridement with no adverse effect onto the underneath cemental layer. Radicular debridement encompasses therapy of unhealthy dentition with the help of scaling instruments either hand or machine-driven along with thorough planing of radicular surfaces until a smooth, shiny & properly cleaned surface is obtained. It is inspected carefully using a 1st generation probe, dental explorer or curette for tactile perception of smoothness & calculus-free teeth surfaces.
Nevertheless, conventional tactual perception of areas below the gingival margin with no direct visual accessibility prior to and post therapy is often deficient in exactitude, susceptibility & consistency or reliability; hence leading to redundant cementum eradication along with leftover calcified deposits. Operators are frequently unsure regarding radicular morphology apical to the gingival margin during conventional periodontal therapy without elevation of a periodontal flap exposing the underlying root & bone structures. Radiographic methods are also not accurate detection tool as the residual calcified deposits go undetected occasionally. Thus in order to aid to clinician's decisiveness regarding the continuation or limitation of the therapeutic modality and better treatment planning various calculus-detection technique were introduced in the recent times. These opens new window towards improved detection ability & in turn enhanced therapeutics which directly influences the quality of treatment & overall oral health.
Present calculus detection technique encompasses: Detection-only systems comprising of diminutive endoscope with a laser that initiates teeth surface to fluorescence & Combined calculus-detection & removal systems where ultrasonic oscillating system scrutinizes teeth-reflected impulses & combination system of Er:YAG and diode lasers].
Detection-Only Technology:

Fiberoptic endoscopy-based technology:

Need for adequate visualization of the surface area apical to the gingival margin lead to the modification of the available conventional endoscope into a miniaturized version for periodontal usage. With this, the Perioscopy came into the picture which was launched two decades ago in 2000. Perioscopy is a minimally-invasive minute periodontal device that is placed inside the pathologically deepened gingival sulcus/crevice which allows visualising the teeth radicular areas apical to the marginal gingiva at a magnified version of 24–48X. This technology comprises of fiber-optic package covered by numerous light-illuminating fiber bundles, an illumination point-source, water irrigating unit & attached visual-display monitoring device. Operators can instantiate the shape & morphology of the radicular teeth surfaces apical to the gingival margin along with the inspection of any leftover calcified plaque deposits in real time; with the observation & visualization of the enlarged pictures on the adjacent display unit. Thereafter the still and motion pictures are recorded & stored in the hard drive for future references. It assists in specific detection & absolute eradication of calcified flecks of plaque during conventional mechanical debridement through precise imaging of the operated subgingival areas.

In the recent past; periodontal research revolved around the effectiveness of a dental endoscope in aiding to periodontal therapy. Unresponsive diseased sites with increased depth of periodontal pocket were managed using mechanical debridement of the radicular surfaces alone or in combination with the application of periodontal endoscopy technique [11]. In comparison to the baseline data, statistically insignificant deviations were noted regarding the pocket depth deduction in both the categories following therapy post 1 & 3-months duration. Furthermore; GCF or sulcular fluid output, IL-1beta amounts were reduced in both categories with no intergroup statistical significance. Moreover, elongated time duration for therapy was encountered for the Perioscopy method with stretching upto 45mins in each experimental area.

Histological examination of the reaction to plaque biofilm eradication along with calcified deposits from the radicular teeth surfaces aided by a Perioscopy technique was assessed [12]. Post endoscope-aided conventional mechanical debridement; teeth were extracted from the subjects enrolled in the research pattern. Histologic analysis revealed the development of long junctional-epithelium due to penetration of epithelial cells to the treated site along with healing by bone repair without any symptomatic indication of presence of persistent inflammatory reaction. A controlled-category undergoing non-surgical periodontal therapy exclusively was not involved; thus the gradational outcome ascribable to Perioscopy application could not be fully ascertained. Altogether, scarce literature is available till present times exploring the effectiveness of incorporation of fiberoptic mechanism to conventional debridement technique. No significant dissimilarity was noted in relation to the deduction in periodontal probing depth post conventional non-surgical therapy or its combination with perioscopy technology. Moreover, histological evidence of healing evaluated succeeding endoscopic-assessed conventional mechanical debridement was not compared to SRP alone which would have given a clearer picture.

Investigation at the miniscule-level of radicular teeth areas succeeding perioscopy-assisted conventional mechanical debridement displayed minute beneficial effects exclusively in the interproximal areas, mostly in anteriors showing deeper periodontal pockets & multi-rooted tooth with comparatively shallower periodontal pockets.

Spectro-Optical Technology:

This technique for discernment of calcified plaque deposits on radicular surfaces utilizes an illuminating semiconductor device (LED) along with fiberoptic mechanism. This technology is presently being applied by only single mechanical equipment named as Detec-Tar. This equipment comprises of compact mobile cord-less handheld piece & attached periodontal probe with a distinctive curvature having millimetre markings to evaluate the depths of pathologically deepened gingival sulcus.

An attributable spectral trademark of dental calculus subgingivally is produced on red-light irradiation by the reflecting phenomenon, absorption process & diffraction. It is discerned by optical-fiber technology followed by conversion to electric sign or indication which later undergoes data processing & analysis by a computerized algorithm.

The radicular aspects of teeth apical to the gingival margin can be assessed by diagnostic equipments with proper tactile perception of the operator but it doesn't provide an exact picture of the accurate morphology or presence of remaining flecks of mineralized accumulation. Whereas, this advanced technology scans the radicular areas subgingivally with no application of tactual force. On detection of calcified mineralized deposition; the clinician collects the data on its confinement by auditory & illuminated signalling technique. The identification potential of mineralized deposits located apically in-vitro was evaluated in recently uprooted periodontally compromised teeth & the reported findings were correlated with clinical recordings as well as corresponding histologic evidence [13]. Furthermore, the effect of various tip angle alignment of fiber-optical probe-end & entirely enveloping filtrate like blood or saliva were analysed. The significance was marginally affected by nature of the irrigating liquid which was noticed to be 100% in case of blood fluids & almost hundred percent in saline by any applied aligned angle of the probe.

The efficacy of spectro-optic technique for eradication of mineralized accumulation from the subgingival radicular aspects of teeth was assessed in a controlled study-design [14]. The non-treatment teeth areas, in the controlled category, were analysed utilizing the Detec-Tar. Whereas in the therapy category, therapeutic remedy commenced on acquiring definitive indicator sign from the spectro optical equipment & therapy was carried on till negative signalling was generated. Clinically detected calculus was registered post ocular-microscopic evaluation succeeding teeth unsheathing. After evaluation of the teeth areas that previously indicated the presence of mineralized deposits & consequently underwent therapy till the device showed negative indicator; showed that 17% of specified parts were partially enveloped with calculus with contract to 83% sites completely freed of any mineralized deposition on the radicular surfaces. However, 41% of sites which previously showed the absence of mineralised accumulation & thus did not underwent therapy eventually harboured calculus.

Autofluorescence-Based Technology:
Inherent ability possessed by the mineralized deposits to release luminescence after illumination using a specified wavelength of light helps in identification of the mineralized accumulation apical to the gingival margin. Various research designs were modulated to analyse the auto-fluorescence ability of the radicular teeth areas as well as attached calcified mineralized deposits [15,16'17]. Various distinctive fluorescence bands in the range of 570-730nm were observed on samples of mineralised depositions that evoked with illumination of approximately 400nm wavelength, whereas it went undetected on the spotless or thoroughly cleaned radicular aspects [18]. For distinguishing specific deposits on periodontally-healthy teeth, a typical fluorescence-ratio based technique working on the principles of autofluorescence which is produced by 405nm bluish LED was created.
The recently developed detection equipment, Diagnodent, working on the principle of autofluorescence that escalates post exposure to red-illumination stimulant, affirms to differentiate periodontally-healthy from caries-affected teeth surfaces. A InGaAsP-based red-laser LED passes light rays of a specified wavelength via optical-fiber upon radicular teeth plane, that is eventually initiated to fluoresce. The bright emission reflected from the investing teeth structures is arrested via enveloping optical-fibers, following transmission to desegregated semiconductor device or photodiode that acts as fluorescence indicator. Visual upshots due to illuminated reflection are gradually obliterated by a filter medium followed by modulation of autofluorescence luminosity.
The magnitude of autofluorescence is calculated, converted as well as exhibited on digitalized platform comparative to mineralized deposits in a scale of 0-99 as calculus identification units. In relation to the prefabricated producer's guidelines, more than 40units is indicative of presence of calcified deposition; while ranging from 5-40 is considered as minute amounts of detected mineralized plaque accumulation on radicular aspects alternatively to remaining deposits after fragmentary teeth cleansing. Similarly, quantitative amounts of less than 5 are determined as thoroughly immaculate teeth areas. Calculus detection is designated by a beeping noise in the device which is automatically intensified as the quantitative measurements in the display-screen gradually escalate. Exfoliated areas of periodontally-compromised teeth that was partially enveloped with mineralised deposits as well as dampened with associated fluids are scanned with the help of this machine [19,20]. The obtained identification beeping-sounds are evaluated along with clinical recording as well as histologic results. Existence of mineralized accumulation outstandingly corresponds with the elevated fluorescence strength detected.

Combined Detection/Treatment Technology:
Ultrasonic Technology:
This mineralized plaque-detecting mechanism works on the principle of a traditional piezoelectric ultra-sonic vibration scaler which is identical to the manner of detecting breach or fissure on glass surface in acoustic way by knocking onto its brim with a metallic utensil. The insert of a traditional ultra-sonic scaler obtains minuscule, frail stimulations alongside a standardized constancy of approx. 50Hz that leads to the oscillation of the far-end point upon constant frequency which is contingent on features of superficial layer. These repetitive vibrations are directed to an associated piezoceramic disk that converts it to electric potential difference or electric pressure. This electric tension level corresponds to the end-point oscillation strength; whereas a constant repetition-frequency is maintained throughout. An all-inclusive sign or indication; compiled by addition of impulse stimulation along with reaction/response; is analysed with the help of a automated computerized-technique; thus obtaining detailed statistical knowledge regarding specific features of superficial area.
Periodontal ultra-sonic equipment, PerioScan, is furnished with an identification action-mode which helps differentiate mineralized plaque accumulations from thoroughly spotless radicular aspects of teeth. It also supplies a remedial or therapy oriented action-mode which helps provide traditional ultra-sonic periodontal therapy at variant power-extents. Once the equipment end-point comes in contact with radicular teeth aspects, resultant indication is determined by illuminated sign in hand-held piece as well as table-top attached exhibition component; where greenish radiation specify cemental surface & bluish hue confirms the presence of mineralised disease-causing bacterial accumulation.
On identification of mineralised deposits on radicular plane, added acoustically-represented auditory signs are activated & this identification action-mode is switched on exclusively when periodontal therapy is not commenced. Both the identification as well as therapy action-mode can be simultaneously activated for the superficial aspects of the similar teeth. On encountering mineralized depositions, radicular teeth plane can be operated using a high-voltage setting; although in its absence conventional therapy can be rendered at a minimal voltage range wherein only the eradication of the bacterial-biofilm has to be done schematically. Limited literatures in research works, encompassing practical implementation of periodontal ultra-sonic equipment trail, for precision in identification of mineralised depositions are available. Identification of presence of calcified depositions was established upon radicular teeth aspects apical to gingival margin, which was later correlated with the visible recordings noted post teeth exfoliation [21]. Additive effectiveness of implementation of mineralised deposits detection-mode along with ultra-sonic technique for eradication of calcified plaque is still not explored in depth.

Laser-dependent mechanism:
Er:YAG laser is contemplated to be a predominant prevailing agent with blooming results in periodontal treatment modality, because of its functional ability to eradicate investing tissues with no excessive heat-related deleterious consequences. It is based on the principle of photoablation. These works by emission of pulsed infra-red radiation of a specific wavelength, imbibed to a greater degree effectively by almost entire biotic tissue/matter having aquatic composition.
This radiation-activated tissue vaporization leads to fluid emancipation, thus causing collateral heat-reduction in surrounding investing structures. Nonetheless, on its application to tooth-related bone structures having reduced quantity

of fluid content, causes elevated levels of heat production; so irrigating is essential to decrease or maintain the temperature gradient which helps prevent any detrimental effect. Therapeutic effectiveness of lasers in relation to eradication of mineralized radicular deposits was statistically comparative to traditional mechanical therapy showing similar outcomes. Heat-related deleterious effect onto the radicular teeth aspects was noted to be minimal or absent when laser application was done at a reduced range of irradiation along with subsequent cooling provided by fluid irrigating method [17,22].
Several research designs showed promising outcome of the laser application by production of health-compatible radicular teeth aspects following eradication of lipopolysaccharides along with calcified deposition which favours PDL-fibroblast attachment as well as deduction of disease-causing microbial accumulation [23,24]. In contrary, it was equivalently documented that laser caused elevated eradication of gingival tissues during therapy; produced superficial surface irregularity as well as decreased efficiency in elimination of mineralized plaque in comparison to conventional non-surgical periodontal therapy [17]. Efficiency in elimination of mineralized deposits from radicular surfaces is subject to applied radiation range. Moreover, implementation of elevated radiation to the teeth aspects leads to enhanced non-desirable superficial structure loss on application to periodontally-healthy surface [17,22].
Exclusively merchandised equipment named Keylaser3TM; KaVo; works on combination principle of identification & therapy modality in a response-based fashion for elective eradication of calcified deposits. This amalgamated identification machine is established on InGaAs-laser in order to identify mineralised accumulation on radicular plane by autofluorescence along with Er: YAG-laser for therapeutic purpose rendering it disease-free; thus promoting oral health improvement. Later mentioned laser-irradiation for effective therapeutics is solely triggered for illumination discharge when a previously set autofluorescence threshold-degree for identification-laser shows elevated markings on the scale staring from 0 upto 99. Therapeutic Er: YAG-laser is switched off automatically once the values are decreased beneath the designated threshold-values. This merged technique including both the detection as well as treatment modality laser technology was best formulated in order to enhance effective elimination of calcified deposits with minimal undesirable adverse effects of Er: YAG-laser.
Various clinico-histologic research have proved the effectiveness of laser-dependent identification technique amalgamated with therapeutic modality for eradication of mineralised deposits from radicular teeth plane apical to gingival margin with preservation of superficial tooth structure. Moreover, the obtained outcome was similar to conventional debridement using manual or ultra-sonic equipment; but controlled-longitudinal study designs with long-term follow up was not thoroughly documented which could have demonstrated a clearer picture.
Further researches are guaranteed in order to determine the efficiency of these amalgamated equipments application leading to improved therapeutic results; showing subsequent reduction in probing pocket depth, a deducted necessity for periodontal surgical treatment as well as reduced post-operative dentinal hypersensitivity.

Newer Non-Periodontal Probes:
Calculus Identification:
Mineralized plaque discernment probes spot deposits apical to the gingival margin utilizing auditory markings which is described to enhance the detection capability of subgingivally located calcified depositions. Presently, DetecTar probe is the available mineralised plaque identification instrument that leads to improved detection procedure; thus ensuring effective removal & promotion of overall oral health.
It is an equipment with an attached light-weighted & balanced hand-held piece that is autoclavable & provides an auditory beeping sound or signal indicating the identification of subgingival mineralized deposits on radicular teeth aspects. This beeping sound can also be discontinued. Detec-Tar helps supplement the traditional techniques for calculus identification and not replace it. However, this is high-priced as well as the hand-held piece is heavier than a conventional periodontal probe which are the major disadvantages that hampers effectiveness of its usage. It comes with a shorter waterline attachment which hinders the agronomical positioning of it. Similar to the rest of the automated advanced probes, it is also subjected to false positive/negative; thus future investigation is indispensable to authenticate the application of this automated probe.

Periodontal Disease Evaluation System:
Diamond probe:
The Diamond Probe/Perio 2000 System allegedly identifies periodontitis in traditional clinical evaluation by quantifying comparative sulfide conc. as a detector of gram-negative microbial activity. It constitutes a onetime-use dispensable probe-tip with micro-sensors attached to the central controlling system. It helps detection of periodontal disorder at the initial phase as well as identification of active spot requiring therapy.
Nevertheless, probing force applied is not standardized; thus inter-examiner variation is anticipated. In the similar manner, periodontitis can also be produced by microbial colony not emitting volatile-sulphur components; thus generating possibility for certain disease-activity to be overlooked.

Periotemp probe:
The Periotemp Probe is a temperature-sensitive probe that subjectively helps detection of initial inflammatory shifts in the associated gingival structures by measurement of heat-related variance among them. It distinguishes periodontal-pocket temperature dissimilarity of 0.1ºC from a standardised heat condition subgingivally. It consists of 2light indication diodes. Red emission signifies relatively elevated temperature gradient indicating higher risk factor for succeeded loss of clinical attachment; where the green irradiation denotes a lesser temperature showing comparatively low risk sites.

It helps in initial identification of the inflammatory reactions; thus therapeutic modality can be activated at a preliminary phase. But, existence of superficial cooling by breadth air-flow might cause supplementary entangling in the establishment of overall usual temperature disposition.

CONCLUSION

These advanced diagnostic technologies serves as a promising agent that can be incorporated in routine clinical practice to augment the conventional periodontal evaluation methods. It helps overcome the shortcomings in traditional techniques due to various designs of the diagnostic instruments, force application while periodontal probing or variations in tactile assessment of radicular surfaces & soft tissue due to varied extent of gingival tissue inflammation. The prime factor supporting its application as adjunctive measure to traditional diagnostic aids is that it is safer; employing non-ionizing radiation & provides the accurate picture without displacing the investing tissues or perforating the underlying junctional epithelium. Incorporation of technology-assisted therapy will help in improvement of not only actual precise detection but also long-term periodontal therapy outcome.

REFERENCES

1. Cobb CM. Non-surgical pocket therapy: mechanical. Ann Periodontol 1996: 1: 443–490.
2. Pihlstrom BL, Ammons WF. Treatment of gingivitis and periodontitis. Research, Science and Therapy Committee of the American Academy of Periodontology. J Periodontol 1997: 68: 1246–1253.
3. Van der Weijden GA, Timmerman MF. A systematic review on the clinical efficacy of subgingival debridement in the treatment of chronic periodontitis. J Clin Periodontol 2002:29(Suppl 3): 55–71.
4. Cobb CM. Clinical significance of non-surgical periodontal therapy: an evidence-based perspective of scaling and root planing. J Clin Periodontol 2002: 29(Suppl. 2): 6–16.
5. Kocher T, Konig J, Hansen P, Ruhling A. Subgingival polishing compared to scaling with steel curettes: a clinical pilot study. J Clin Periodontol 2001: 28: 194–199.
6. Nyman S, Westfelt E, Sarhed G, Karring T. Role of ‘‘diseased’’ root cementum in healing following treatment of periodontal disease. A clinical study. J Clin Periodontol 1988: 15: 464–468.
7. White DJ. Dental calculus: recent insights into occurrence, formation, prevention, removal and oral health effects of supragingival and subgingival deposits. Eur J Oral Sci 1997:105: 508–522.
8. Blomlof L, Lindskog S, Appelgren R, Jonsson B, Weintraub A, Hammarstrom L. New attachment in monkeys with experimental periodontitis with and without removal of the cementum. J Clin Periodontol 1987: 14: 136–143.
9. Hughes FJ, Smales FC. Immunohistochemical investigation of the presence and distribution of cementum-associated lipopolysaccharides in periodontal disease. J Periodontal Res 1986: 21: 660–667.
10. Nyman S, Sarhed G, Ericsson I, Gottlow J, Karring T. Role of ‘‘diseased’’ root cementum in healing following treatment of periodontal disease. An experimental study in the dog. J Periodontal Res 1986: 21: 496–503.
11. Avradopoulos V, Wilder RS, Chichester S, Offenbacher S. Clinical and inflammatory evaluation of Perioscopy on patients with chronic periodontitis. J Dent Hyg 2004: 78: 30–38.
12. Wilson TG Jr, Carnio J, Schenk R, Myers G. Absence of histologic signs of chronic inflammation following closed subgingival scaling and root planing using the dental endoscope: human biopsies - a pilot study. J Periodontol 2008: 79: 36–41.
13. 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.
14. Kasaj A, Moschos I, Rohrig B, Willershausen B. The effectiveness of a novel optical probe in subgingival calculus detection. Int J Dent Hyg 2008: 6: 143–147.
15. Brayer WK, Mellonig JT, Dunlap RM, Marinak KW, Carson RE. Scaling and root planing effectiveness: the effect of root surface access and operator experience. J Periodontol 1989: 60: 67–72.
16. Cobb CM. Lasers in periodontics: a review of the literature. J Periodontol 2006: 77: 545–564.
17. Folwaczny M, Mehl A, Haffner C, Benz C, Hickel R. Root substance removal with Er: YAG laser radiation at different parameters using a new delivery system. J Periodontol 2000: 71: 147–155.
18. Buchalla W, Lennon AM, Attin T. Fluorescence spectroscopy of dental calculus. J Periodontal Res 2004: 39: 327–332.
19. Folwaczny M, Heym R, Mehl A, Hickel R. Subgingival calculus detection with fluorescence induced by 655 nm InGaAsP diode laser radiation. J Periodontol 2002: 73: 597–601.
20. Krause F, Braun A, Frentzen M. The possibility of detecting subgingival calculus by laser-fluorescence in vitro. Lasers Med Sci 2003: 18: 32–35.
21. Meissner G, Oehme B, Strackeljan J, Kocher T. Clinical subgingival calculus detection with a smart ultrasonic device: a pilot study. J Clin Periodontol 2008: 35: 126–132.
22. Aoki A, Ando Y, Watanabe H, Ishikawa I. In vitro studies on laser scaling of subgingival calculus with an erbium:YAG laser. J Periodontol 1994: 65: 1097–1106.
23. Ando Y, Aoki A, Watanabe H, Ishikawa I. Bactericidal effect of erbium YAG laser on periodontopathic bacteria. Lasers Surg Med 1996: 19: 190–200.