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Recent Advances in Calculus Detection and Removal –A Review

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Abstract: *Periodontal disease is one of the most prevalent disease which is caused mostly by dental plaque or biofilm which later calcified to form dental calculus.Early detection of calculus and its removal thus plays a pivotal role in preventing the progression of periodontal disease.There are currently a plethora of novel modalities in the detection as well as removal of dental calculus.Thispaper will give an overview of these umpteen modalities and its applications in the field of periodontics.*
Keywords: *Calculus,spectro-optical, autoflourescence,ultrasonics,laser*

I. Introduction

Periodontal disease and dental caries are the two most prevalent dental infections affecting the mankind[1] Dental plaque or biofilm is the most common aetiologic factor for these diseases which is a defined as "matrix enclosed bacterial population adherent to each other and/or to surfaces or interfaces".[2]Dental plaque undergoes mineralisation which leads to calculus formation. A continuous exchange of ions is always happening on the tooth surface with a constant exchange of calcium and phosphate ions. This leads to formation of calculus which in turn can aggravate the disease process.[3,4,5]

Calculus has been considered as a major aetiological factor for periodontal disease since Sumerian period. Hippocrates, the father of medicine, formally announced the deleterious effects of "pituita" (calculus) present under the root surfaces. Later Abulcasis as well as Paracelsus emphasized on the removal of calculus to halt the disease process. Numerous treatment modalities have been offered for removal of calculus. Currently employed treatment strategies include; hand and ultrasonic instruments, rotary instruments and lasers. Thorough scaling and root planing which involves the removal of deep seated subgingival calculus is a key step in halting the disease process. Detection and subsequent removal of this deep seated calculus is hampered by the location, vicinity and inflamed gingival conditions. Calculus can be defined as a hard concretion that forms on teeth or dental prostheses through calcification of bacterial plaque.[7] Depending upon its location calculus can be classified as either subgingival or supragingival. Various studies carried out to reveal the presence of calculus have shown that calculus is present in 70-100% cases. These studies do not discriminate between supra and subgingival calculus but they indicate high prevalence of calculus in all studied populations.[8]Calculus is primarily composed of calcium phosphate salts covered by an unmineralized bacterial layer. Inorganic content of calculus matches that of bone, dentine and cementum. It mainly consists of dicalcium phosphate dehydrate, octacalcium phosphate, substitutedhydroxyapatite and magnesium substituted Tricalcium phosphate (whitlockite). Structure of calculus largely resembles that of dentine, which is porous in nature. Hence it can provide a niche for bacterial growth.[8,9]

Mechanical Debridement (Hand And Ultrasonic Instruments)

Non-surgical periodontal therapy is still considered cornerstone of periodontal treatment. Effectiveness of this therapy lies in reducing the bacterial load from periodontal pocket and removal of hard deposits like calculus that cause aggravation of the infection. Studies done to assess effectiveness of different treatment modalities in calculus removal concluded that complete removal of calculus from root surfaces is impossible.

Hand Instruments

Numerous hand instruments are used for non-surgical periodontal therapy. Scalers and curettes are the mostcommonly used. Area specific curettes provide maximum access to subgingivalcalculus.Different aspects of hand instrumentation have been compared with ultrasonic instrumentation. One study has shown that ultrasonic inserts consumed less time to remove calculus when compared to Gracey curettes. In a different study no microscopic difference was found between Cavitron™ ultrasonic scaler and Graceycurettes.[11,15,29]

Ultrasonic Instruments

Ultrasonic instruments have greatly taken over as the unique treatment modality for removing plaque and calculus. Ultrasonic instruments are power driven instruments which oscillate at very high speeds causing micro vibrations which aid in removal of calculus and subgingival plaque. Recent studies have shown that both modalities oscillate in a similar pattern producing similar defects on the root surface. Magnetostrictive and piezoelectric instruments as well as ultrasonic and hand instruments have been compared with each other. One

such study has shown that piezoelectric system is more efficient in removal of calculus compared to other two but they left tooth surface more rougher.[11] Certain other studies have produced conflicting results. Hence it is not exactly clear which treatment modality is better and more efficient in removal of plaque and calculus from root surface.

Vector™ System*

Vector™ system is specially devised to reduce the amount of tooth surface loss and treat the periodontal tissues less aggressively. Uniqueness of this system lies in the oscillations produced by the ultrasonic tip. Ultrasonic tip of this system vibrates parallel to the tooth surface, which leads to less removal of the tooth structure.[16]

Vector™ system is recommended for use in conjunction with irrigation fluids containing hydroxyl-apatite or silicon carbide. Studies have shown that this system removes calculus efficiently. However, efficiency of the removal is dependent on the abrasive fluid used.[17]One more advantage of this system lies in the reduction in pain perception of the patient. This may be attributed to vertical vibrations of the ultrasonic tip. Studies have shown that abrasive fluid forms a smear layer on scaled tooth surfaces. This smear layer is responsible for reduction in postoperative hypersensitivity.[18] Vector™ system is least efficient when polishing fluid is used with straight metal tip. Use of the abrasive fluid has shown to cause tooth substance loss comparable to hand instruments.Hence, Vector™ system can be an efficient adjunct for scaling and root planing. It can also decrease the pain sensations during treatment owing to type of oscillations of the tip. But further studies are warranted to assess the efficacy of this system for in vivo use.

Lasers

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. Maiman first introduced laser device in 1960. The advantage of lasers lies in the fact that lasers can concentrate the light energy at a single point and target the tissues accordingly. Kinersly et al (1965) first used ruby lasers for removal of calculus from tooth surfaces.[19]Various types of lasers are used in the field of dentistry. Depending on the frequency lasers can cut hard tissues or soft tissues. Nd: YAG laser has been approved by FDA in 1990 primarily for soft tissue surgeries and in 1999 for use on hard tissues. This laser can also be used for removal of calculus. Various studies have shown Nd: YAG laser demonstrates partial removal of calculus from root surface. Extensive studies have been carried out on Er: YAG laser since its introduction by Zharikov in 1974.[20]Er: YAG laser is primarily absorbed in water making it an ideal for hard tissue ablation. Absorption in water causes less damage to hard tissues owing to less amount of heat production. Studies done to assess the efficacy of lasers in calculus removal have shown comparable results with hand and ultrasonic instruments. Er: YAG lasers cause comparable loss of root substance to hand instruments.[21]It has been reported that lasers cause approximately 40-136µm deep ablation of cementum.[22]Lasers when compared to ultrasonic instruments for their efficacy in calculus removal lasers have shown inferior results to ultrasonic instruments.[23]

II. Detection Of Calculus

Current treatment strategies for removal of biofilm are based on non-specific plaque hypothesis which considers biofilm as a whole for initiation of disease. Hence non-surgical periodontal therapy comprises of thorough removal of plaque and calculus from root surfaces. Most important aspect of these modalities is detection of calculus using tactile sense of the operator. Visibility is a major factor that limits detection of sub-gingival calculus. Hence operator has to rely on either periodontal probe or explorer or curette to detect the presence of subgingival calculus. Smooth and clean root surface is often considered as the endpoint of scaling and root planing. Clinicians tend to remove excess amount of root structure due to hampered visibility to achieve a smooth rootsurface.To counteract the above stated problem many systems have been developed to aid the clinician for detection of calculus. These systems are broadly classified as calculus detection systems and systems with combination of detection and removal[23, 24, 25]

Diagnodent™

Calculus and tooth structure differ in composition. This structural difference gives a typical fluorescence to both these structures. Calculus contains various non-metal as well as metal porphyrins and chromatophores which make it able to emit fluorescent light when irradiated with a light of certain wavelength. Diagnodent™ 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.As per some studies ,calculus detection using autoflourescence resulted in a significantly smaller total area covered with residual calculus than if diagnostics was based on a conventional explorer.

Detectar™

DetecTar™ uses a Spectro-optical approach in order to detect subgingival calculus by utilizing a light emitting diode and fiberoptic technology. This involves an optical fibre which recognizes the characteristic spectral signature of calculus caused by absorption, reflection and diffraction of red light.The signal is sensed by the optical fibre which is converted into an electrical signal which is analysed by a computer processed algorithm.TheDetecTar device comes as a portable cordless handpiece with a curved periodontal probe that has millimetre markings to measure pocket depths.Without any tactile pressure the subgingival root sirface can be scanned by the instrument.As soon as calculus is detected ,the operator receives the information on calculus localization by audible and luminous signals.[11,29]

Perioscopy™

Perioscopy involves a modified medical endoscope exclusively for periodontal purpose. This was developed in year 2000. It consists of a 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 structure and calculus in real time on a display monitor.[11]

Perioscan™

Perioscan™ 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.[11]
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.[26]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%

Merits

1..Handpiece contains fiberoptic system to enhance the visibility of the operator.
2. Less incidence of overzealous instrumentation
3.. Acoustic system can help the colour blind operator in better assessment of the calculus.
4. Less amount of healthy tooth substance removal.
5. No additional equipment is necessary due to provision for scaling is embedded in the device.
6. Easy detection of subgingival calculus with different colours denoting presence or absence of calculus

Demerits

1. Low specificity
2. Root surface irregularities can be mistaken for calculus.

Keylaser3™

Keylaser3™ combines a 655nm InGaAsP diode for detection of calculus and a 2940nm Er: YAG laser for treatment. Previous versions of this system (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. Cost factor can be a limiting aspect for using lasers for detection and treatment[11,29]

Keystone Hypothesis –The Recent Theory By George Hajishengallis

Recent studies have highlighted the importance of the human microbiome in health and disease. However, for the most part the mechanisms by which the microbiome mediates disease, or protection from it, remain poorly understood. The keystone-pathogen hypothesis holds that certain low-abundance microbial

pathogens can orchestrate inflammatory disease by remodelling a normally benign microbiota into a dysbiotic one.[30]

III. Conclusion

There are a umpteen number of 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%.[27,28,29] With the emerging concepts of Ecological and specific plaque hypothesis, and the recent keystone hypothesis, smoothening of root surfaces is not deemed necessary for achieving periodontal regeneration, however no periodontist will like to leave out a rough, unclean surface behind at the end of the treatment. To achieve a clean, smooth root surface, clinicians inclined towards overzealous instrumentation. Postoperative sensitivity and pulpitis is a major problem associated with such instrumentation. Studies have shown that approximately 20 strokes of hand instrument were sufficient to remove complete layer of cementum from the root surface. Recent studies have also shown that endotoxins released by bacteria are not firmly adherentto root surfaces and can be removed by systematic instrumentation. Hence current treatment strategies rely on tactile sense to detect calculus so as to achieve proper root debridement.Deep pockets, furcal openings as well as variations in tooth anatomy complicate the issue further by making them inaccessible to non-surgical periodontal therapy..Perioscan™ equipped with inserts can prove handy in such situations.With the knowledge that remnant calculus can lead to periodontal abscesses it becomes so important 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 specific 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.[29]A plethora of techniques have been used to identify calculus deposits present on the root surface.. 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. Perioscan™ which detects and removes the calculus simultaneously may be a useful tool in the hands of a general dentist with a regular clinical setup and can turn out to be a valuable adjunct in the clinician's armamentarium for efficient scaling along with minimal removal of healthy tooth substance. In comparison to other instruments used for calculus detection and removal .There are lots of studies currenly going on pertaining to this and the proper implementation of such novel technologies with the involvement of Government so that it should be made available at tertiary healthcare systems so that the majority the common men who are always being downtrodden may get benefitted.There should be cost effective measures which helps in the detection of calculus at early stage so that the progression can be halted and more preventive strategies can be undertaken.

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