Review Article

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DENTAL CALCULUS: A STRATEGIC REVIEW

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ABSTRACT:

Dental calculus or tartar is an adherent calcified mass that form on the surface of teeth and dental appliance through mineralization of bacterial dental plaque in aqueous environment. Dental calculus plays a vital role in aggravating the periodontal disease by acting as reservoir for the bacterial plaque and providing the protected-covered niche for bacteria to proliferate. Based upon the location of dental calculus in relation to marginal gingiva, it is classified into mainly two types: 1. Supragingival calculus and subgingival calculus. Calcium and phosphate are two salivary ions which are raw materials for dental calculus formation. The various techniques and equipments involved for calculus removal is Hand Instruments, Ultrasonic, Ultrasound Technology and Lasers. Chemotherapeutic agents have been used to supplement the mechanical removal of dental plaque, but a more potent oral rinse with anti-calculus properties to prevent mineralization will be the need of time to suppress calculus formation.

Key Words: Periodontitis, Anti-calculus, Periogen.

INTRODUCTION:

Periodontitis is a destructive inflammatory disease of the supporting tissues of the teeth and is caused either by specific microorganisms or by a group of specific microorganisms, resulting in progressive destruction of periodontal ligament and alveolar bone with periodontal pocket formation, gingival recession, or both. [1] The oral cavity appears as an open ecosystem, with a dynamic balance between the entrance of microorganisms and colonization modalities. [2] Biofilms are ubiquitous; they form on virtually all surfaces immersed in natural aqueous environments. Biofilms form particularly fast in flow systems where a regular nutrient supply is provided to the bacteria. The reason for the existence of the dental biofilm is that it allows the micro-organisms to stick and to multiply on surfaces. [3] Mineralization of dental plaque leads to calculus formation. Dynamic state of tooth surface is responsible for mineralization of plaque. A continuous exchange of ions is always happening on the tooth surface with a constant exchange of calcium and phosphate ions. The whole process leads to the accumulation of dental plaque which in turn forms dental calculus. Dental calculus plays an instrumental role in further infuriating the periodontal disease.

Dental calculus or tartar is an adherent calcified mass that form on the surface of teeth and dental appliance through mineralization of bacterial dental plaque in aqueous environment. Dental calculus is layered by non-mineralized bacterial

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plaque; hence act as reservoir of microorganisms in the oral cavity. 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. [4]

CLASSIFICATION:

Based upon the location of dental calculus in relation to marginal gingiva, it is classified into mainly two types:

1. Supragingival calculus
2. subgingival calculus.

Supragingival Calculus:

Supragingival calculus is located coronal to the gingival margin and therefore is visible in the oral cavity. It is usually white or whitish yellow in color, hard with clay-like consistency, and easily detached from the tooth surface. The color is influenced by contact with such substances as tobacco and food pigments. It may localize on a single tooth or group of teeth, or it may be generalized throughout the mouth. After removal, it may rapidly recur, especially in the lingual area of the mandibular incisors. The two most common locations for supragingival calculus to develop are the buccal surfaces of the maxillary molars and the lingual surfaces of the mandibular anterior teeth. Saliva from the parotid gland flows over the facial surfaces of upper molars via Stensen's duct, whereas Wharton's duct and Bartholin's duct empty onto the lingual surfaces of the lower incisors from the submaxillary and sublingual glands, respectively. [5] Supragingival calculus is composed of more brushite and octacalcium phosphate with less magnesium whitlockite. Salivary proteins are present and sodium content is less.

Subgingival Calculus:

Subgingival calculus is located below the crest of the marginal gingiva and therefore is not visible on routine clinical examination. The location and extent of subgingival calculus may be evaluated by careful tactile perception with a delicate dental instrument such as an explorer. Subgingival calculus is typically hard and dense and frequently appears dark brown or greenish black in color while being firmly attached to the tooth surface. Supragingival calculus and subgingival calculus generally occur together, but one may be present without the other. Microscopic studies demonstrate that deposits of subgingival calculus usually extend nearly to the base of periodontal pockets in chronic periodontitis but do not reach the junctional epithelium. When the gingival tissues recede, subgingival calculus becomes exposed and is therefore reclassified as supragingival. Thus supragingival calculus can be composed of both supragingival calculus and previous subgingival calculus. A reduction in gingival inflammation and probing depths and a gain in clinical attachment can be observed after the removal of subgingival plaque and calculus. [5] Subgingival calculus is composed of less brushite and octacalcium phosphate with more magnesium whitlockite. Salivary proteins are absent and sodium content is more.

Plaque Mineralization Process:

Calculus Formation

The mineralization of dental plaque is a complex process and calcification has been reported to occur as soon as 4 to 8 hours. The soft plaque is hardened by the precipitation of mineral salts, which usually starts between the 1st and 14th days of plaque formation. Calcifying plaques may become 50% mineralized in 2 days and 60% to 90% mineralized in 12 days. [5, 6] Within 24-72 hours of plaque formation, more and more mineralization centers develop close to the underlying tooth surface. The centers grow large enough to touch and unite. The average time for mineralization by rapid calculus formers is 10-12 days and slow calculus former is 20 days. Mineralization can begin as early as 24-48 hours. Calculus forms in layers that are parallel to the tooth surface. The layers are separated by line that appears to be pellicle which later undergoes mineralization. These lines are called incremental lines. Calcification starts in separate foci on inner surface of plaque, these foci of mineralization gradually increases in size and coalesce to form a solid mass of calculus. [7] The mineralization of plaque is illustrated in Table 1. Calcium and phosphate are two salivary ions which are raw materials for dental calculus formation. Theoretically, super saturation of saliva, especially plaque fluid, with respect to calcium phosphate salts is the driving force for dental plaque mineralization. Ion product (Ip) and solubility product (Ksp) are important for estimation of saturation degree (SD) with respect to a given salt. If Ip > Ksp, the fluid is supersaturated and precipitation of the salt can occur; if Ip = Ksp, the fluid is just saturated with respect to the salt, and if Ip < Ksp, the salt tends to dissolve, since the fluid is not saturated with respect to the salt. [8] The rate of calculus formation varies from person to person and can be increased by such factors as elevated salivary pH, concentration of salivary calcium, urea, bacterial proteins or lipids. Four modes of attachment of calculus to tooth surface have been observed [5, 7]:

1. Attachment by means of an organic pellicle.
2. Mechanical locking into surface irregularities such as resorption lacunae and caries.
3. Close adaptation of calculus undersurface depressions to the gently sloping mounds of the unaltered Cementum surface.
4. Penetration of calculus bacteria into cementum.

The various theories associated with theories of calculus formation are illustrated in Table 2.

Composition of Dental Calculus:

Calculus consists of both Inorganic and Organic components as illustrated in Table 3.

Detection of Calculus:

Most significant feature of calculus detection is using tactile sense of the operator. Visibility is a key factor that confines 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. 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 (Ultrasound and Laser Technology).

Eradication of Calculus:

Conventional non-surgical therapy is still considered cornerstone of periodontal treatment. Effectiveness of conventional 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. [9, 10] The various techniques and equipments involved for calculus removal is Hand Instruments, Ultrasonic, Ultrasound Technology and Lasers. 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%. [11, 12, 13]

Future Outlook:

There have been many advances in our perceptiveness of how plaque and microbial mineralization proceeds and regulated by various inhibitors and promoters, and how it can be suppressed and prevented. The roles of macromolecules, such as PRPs, statherins, immunoglobulins, and other glycoproteins, in the initiation of bio-mineralization remain incompletely understood. The potential effects of fluoride on calculus formation need to be clarified. More studies on ureolytic bacteria, which contribute to the increase in plaque pH, are also recommended. Development of biofilm culture systems, notably the “artificial mouth”, could lead to breakthroughs in our understanding of mineralization mechanisms. In the “artificial mouth”, various antibacterial agents, which may be used in future dentifrices and mouth rinses, can be evaluated with regard to their possible inhibitory effects on plaque and calculus formation. The effects of the various anti-calculus agents on plaque mineralization on implant surfaces also need to be confirmed. In addition, safer and more effective calculus control formulations should be a long-term goal in this field. [14]

Mechanical Plaque control i.e. Tooth brushing is valuable mechanical tool in dental plaque removal, but it is still insufficient for the maintenance of oral health. Chemotherapeutic agents have been used to supplement the mechanical removal of dental plaque, but a more potent oral rinse with anti-calculus properties to prevent mineralization will be the need of time to suppress calculus formation. Calculus dissolution based oral rinse like Periogen® (Periogen Company-USA) with key ingredients of Tetrapotassium Pyrophosphate (TKPP), Sodium Tripolyphosphate (STPP), Sodium Bicrbonate, Sodium Fluoride and Citric Acid seems to be potential oral rinse for suppressing the mineralization of dental plaque when used on regular basis as an adjunct to tooth brushing. Calculus dissolution based oral rinse (Periogen®) can be used either by swishing method (For Gingivitis Patients) or through oral irrigator system like WaterPik with Pick- Pocket tip (For Periodontitis Patients) to reach the periodontal pocket depth. The clinical effects of the various anti-calculus agents including (Periogen®) on prevention of plaque mineralization on dentition and implant surfaces need to be monitored scientifically in longitudinal multi-centric clinical trials.

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TABLES:

Table 1: Mineralization of Dental Plaque

TIME PERIOD	MINERALIZATION PROCESS
0 Day	Clean Teeth Surface (After Professional Prophylaxis)
1-14 Day	Salivary protein rapidly and selective adsorbs onto the enamel surface ↓ Formation of Pellicle ↓ Initial Adhesion and Attachment of Gram-positive Bacteria ↓ Bridging Organism ↓ Gram-negative bacteria/Filamentous bacteria attached to the bridging organism Colonization and Plaque Maturation
15-16 Day **(1-2 Days After Plaque Formation)**	↓ Plaque absorbs calcium and phosphate from saliva for the formation of supragingival calculus and from crevicular fluid for the formation of subgingival calculus (50% Plaque Mineralization)
26 Day (12-20 Days After Plaque Formation)	↓ 60-90 % Plaque Mineralization
10 Weeks/6 Months of Calcification (Reversal Phenomenon)	↓ Calculus formation continues after which there is a decline in its formation due to mechanical wear.

Table 2: Theories of Calculus Formation

THEORY	MECHANISM
Precipitation of Minerals	It results from local rise in degree of saturation of calcium and phosphorus ions, which may occur through following :- ***Booster Mechanism**:* Local rise in Ph of saliva due to factors like loss of Co2, increase production of ammonia ***Colloidal Proteins**:* It connects to calcium and phosphate ions leading to super-saturated solution. With stagnation in oral cavity, colloids settle leading in precipitation of Calcium and phosphorus salts. ***Phosphatase Release**:* It precipitates ccalcium phosphate by hydrolyzing phosphates in saliva, thus boosting ratio of free phosphate ions. ***Esterase:*** is another enzyme that is present in the cocci and filamentous organisms, leukocytes, macrophages, and epithelial cells of dental plaque. Esterase may initiate calcification by hydrolyzing fatty esters into free fatty acids.
Epitactic Concept/Heterogeneous Nucleation	Large calculus formation get initiated by seeding agents (Like ICM of Plaque, biochemical complexes etc) of small foci of calcification.

Table 3: Calculus Composition

Inorganic Component	Calcium, Phosphorus, Carbonate, Sodium, Magnesium, Fluoride. The crystal forms are Hydroxyapatite, Magnesium whitlockite, Octacalcium phosphate and Brushite.
Organic Component	Mixture of protein-polysaccharide complexes, epithelial cells, leukocytes, and various types of microorganisms.