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An Insight into Tooth Factors Affecting Periodontium

[1] Suchetha A
[2] Rashmi Heralgi
[3] Apoorva SM
[4] Rohit Prasad
[5] Bharwani Ashit G

[1] Professor and Head, Dept of Periodontics
DAPM RV Dental College, Bangalore
[2] Assistant Professor, Dept of Periodontics
Al-Ameen Dental College, Bijapur
[3] Senior Lecturer
[4, 5] PG Student
Dept of Periodontics
DAPM RV Dental College, Bangalore

Address For Correspondence:
Dr Rohit Prasad, PG Student,
Dept of Periodontics, DAPM RV Dental College
CA 37, 24th main, JP Nagar 1st Phase
Bangalore-560078, Karnataka
Email: rohitprasad59@yahoo.co.in
Mobile : +91-9886074038

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Abstract
Several conditions exist around teeth that may predispose the periodontium to disease. These situations may occur as a result of the condition or position of teeth or as a result of tooth treatment. In certain cases these tooth-related factors may contribute to the initiation of periodontal disease. While the etiology of periodontal disease is bacterial, factors that enhance bacterial accumulation or allow the ingress of bacteria into the periodontium should be considered in the classification and diagnosis of periodontal diseases. This is because many times these tooth-related issues can cause site-specific problems that require treatment in an otherwise intact periodontium. Several factors related to tooth/root anatomy, have been associated with gingival inflammation, attachment loss, and bone loss. These factors will be discussed in this review, as they relate to their potential to promote damage to the periodontium.

Key Words
Periodontitis, Palato-gingival groove, Furcation, Cervical Enamel Projections

Quick Response Code

Introduction:

Periodontitis is initiated and perpetuated by a small group of predominantly microaerophilic bacteria that colonize the subgingival area. Antigens, virulence factors and invading bacteria comprise the microbial challenge. Inflammation and immune response mounted by the host to the microbial challenge results in production of cytokines, eicosanoids and other inflammatory mediators which perpetuate the response and mediate connective tissue and bone destruction. All these events are influenced by disease modifiers which can be either local or systemic. Local etiologic factors are defined as factors that influence periodontal health status locally but exert no systemic effect. These may be anatomic as well as local iatrogenic factor.[1]

Inherent anatomic and morphologic features of the teeth have significant impact on the etiology of local periodontal disease and management and prognosis of the involved tooth or teeth. These lead to functional and structural changes in dento-gingival junction, increasing its susceptibility to destructive challenge of periodontal pathogens. They thus contribute to the site specific nature of periodontal disease. Awareness of potential anatomic variations and early detection may prevent any future attachment loss.[2]

I. Tooth Related Factors
- a) Tooth position
- b) Open contacts
- c) Marginal ridges

II. Cementum Related Factors
- a) Cemental tears

III. Root Related Factors
- a) Root surface area
- b) Root grooves
- c) Root trunk length
- d) Furcation
- e) Bifurcation ridges
- f) Cervical enamel projections
- g) Enamel pearls
- h) Root concavities
- i) Root proximity

Tooth Position:

The position or inclination of teeth can be factors that predispose the periodontium to plaque accumulation and subsequent loss of attachment. While studies show that areas of periodontium adjacent to malaligned teeth can be maintained in a state of health, in situations where meticulous oral hygiene is not practiced, periodontal disease can occur. There have been conflicted reports on the role of malocclusion in the etiology of periodontal disease.[3]

In a review, two studies have found a correlation between periodontal disease and malocclusion. However, other studies have failed to show a relationship between periodontal disease and malocclusion. One reason for the conflicting reports is that there is no satisfactory index to measure malocclusion. The consensus at present is that crowding of teeth is one of the most important factor of malocclusion with relation to periodontal disease.[4]

Most of the studies dealing with malocclusion and periodontal disease are cross sectional studies often comprising teenagers or young adults. An adverse effect of malocclusion on periodontal health may, in any case not manifest itself until mature age. At times, however it

may be difficult to distinguish between cause and effect, since periodontitis may in itself have caused malocclusion for example increased overjet and spacing of teeth. Longitudinal studies from childhood to adulthood in subjects with persistent trails of malocclusion may therefore provide more valid information.[5] In teeth adjacent to an edentulous site when the tooth migrates or tips mesially, the tipped surface of the teeth can become inaccessible for self performed oral hygiene. This can lead to attachment and bone loss at these sites.[6]
In most studies a strong correlation exists between teeth positioned facially to the dental arch and recession defects. One might assume from these data that malalignment, tooth brush trauma and calculus play more than just a casual role in causation of gingival recession.[7]

Open Contacts:
Several investigations have found open contacts to be modifying factor for periodontal disease. In a study by Blieden et al. it was reported that the percentage of diseased papillae in the areas with weak proximal contact was consistently higher than that found in the areas of good contact.[3] Similarly a number of studies reported a positive association between open contacts and presence of periodontal disease.[8,9]. Whereas another study reported that the significance of open contacts on periodontal disease is very minimal.[10]

Though conflicting reports are present linking open contacts with periodontal disease, Consensus report by 1999 International World Workshop for classification of periodontal disease and conditions has classified open contacts under anatomic tooth factors that predispose/modify periodontal disease.[3] One might assume from these data that malalignment, tooth brush trauma calculus play more than just a casual role in causation of gingival recession.[11]

Marginal Ridges:
Marginal Ridges may exhibit 3 types of variations

1) Uneven in height
2) They may not meet at the contact area because of rotation or malposition of teeth
3) Faulty marginal ridge and sluiceway form (because of restoration or grinding).[12]

Various reports have been published on the importance of marginal ridge relationships. It was stated that it is important for adjacent marginal ridges to be of some heights.[13] Several investigators noted that uneven ridges is a significant predisposing factor in periodontal disease, however, uneven marginal ridges of contiguous posterior teeth are of less importance than the presence and extent of plaque and calculus deposits in determining periodontal health status.[12]

It can be concluded that marginal ridge discrepancy may not be a significant risk factor for development of periodontal disease; however, if a marginal ridge discrepancy leads to an open contact, there may be damage to the periodontium.[13]

Cemental Tears:
The phenomenon of cemental tear has been observed both within unexposed and exposed cementum. The tear or fracture can either occur as a complete separation along the cemento- dentinal border or as a partial split within the cementum following one of its incremental lines. The detachment in unexposed cementum has been related to acute trauma from occlusion.[14] Extracted teeth with cemental tear have been examined to determine whether the presence and extent of attachment loss on the surface having this defect differ from that on the opposite, intact side of the root. The results revealed a significantly greater loss attachment on cemental tear surfaces than on the opposite intact site. Histological examination further indicated that the split between the root and the fragment most likely occurs along the cemento dentinal border.[15]

There are few reports regarding cemental tears. One of the case report suggested the cemental tear fracture could be caused by occlusal trauma.[15] In another report, two kinds of cemental tears were reported. It was suggested that fragments of cementum could be detached by root planning or during surgery and uneventful healing could be obtained, the process of aging in addition to continuous occlusal strain may lead to this problem.[15] Depending upon the location, these factures may or may not be followed by repair. If a cemental tear becomes exposed, or has a close proximity to oral cavity. The likelihood for repair is reduced due to potential bacterial invasion and colonization.[14] Cemental tear may have the potential to initiate an aseptic, rapid, site specific periodontal breakdown in a non infected environment. A complete separation of the fragment with subsequent sequestration can elicit symptoms comparable to acute periodontitis.[1]

Root surface area:
Root surface area, a product of length and circumference of roots, is an important factor in the treatment of the periodontally involved teeth. Total root surface area may vary from 154 mm^2 for the maxillary mandibular central incisor to 433 mm^2 for the maxillary 1st molar .The root surface area of the canines is the second largest in the dentition surpassed only by that of molars. This large area of root surface and the position in the dental arch anterior or to the muscles of mastication, make the canines, mechanically well suited to with stand the forces of mastication.[16]

Root surface area is important because small losses of attachment height caused by inflammatory periodontal disease or gains of attachment following periodontal therapy affect a significant portion of the total support of the tooth. A study was conducted to study linear variations of root surface area in 1mm increments from CEJ to the furcation area and reached maximum dimensions at the level of root separations; approximately 38% of total RSA located within 2mm of root separation. Coronal one half of the root length accounted for 60% of total RSA. Presence of concavities and other root convolutions seen in furcation area also increase the RSA in furcation area.[17]

Root Grooves:
Root grooves are developmental anomalies in which an infolding of the inner enamel epithelium and Hertwigs epithelial root sheath (HERS) creates a groove on the tooth surface.[2] Such morphological features compromise patient's self care, favour accumulation of plaque, calculus and food debris. They facilitate plaque growth and later provide anaerobic condition for bacterial selection and proliferation. They cause patients inaccessibility to routine oral hygiene procedures and they also complicate restorative procedures.[2]
Various types of root grooves have been described [16, 18, 19]

i) Proximal root grooves
ii) Palatal / lingual grooves
iii) Labial cervical vertical grooves

i) Proximal root grooves-

These morphological features occur more frequently in mandibular anterior teeth and maxillary premolar, such concavities are wider in maxillary than in mandibular teeth and are more prone to be exposed early in destructive disease process.[1] A study was conducted on extracted teeth to determine whether the periodontal attachment loss was significantly different for root surfaces with and without proximal root grooves. For incisors and premolars, a significant greater loss of attachment was demonstrated on grooved than on non-grooved surfaces. For premolars, the difference in loss of attachment between grooved and non-grooved surfaces was consistently higher than for incisors and decrease in the effect of root groove with increasing attachment was not seen. These differences between the two groups are presumably related to variation in root groove morphology. While incisors generally display shallow "U" shaped groove that sometimes disappears apically, premolars typically show a more "V" shaped groove which persists towards the apical area. Thus not only the presence of root groove, but also their morphology influences periodontal disease progress.[20]

ii) Palatoradicular Groove / Distolingual Groove / Developmental radicular anamoly / Radicular lingual groove-

These morphological defects are associated with maxillary central and/or lateral incisors. These grooves usually begin in central fossa, cross the cingulum and extend apically for various distances and direction. The prevalence of this anatomic root characteristic has been reported to be 0.5% on a subject basis. Most palatogingival grooves (93.8%) are detected in maxillary lateral incisor teeth and 58% extend more than 5mm apical to CEJ1. The epithelial attachment in this area is normally diseased, forming a ready pathway for the ingress of bacterial endotoxin and the formation of an infrabony pocket.[21]

A study by *Leknes* et al. reported unsuccessful attempts to treat periodontal lesions associated with PRG and suggested that extraction of the involved tooth is the choice of treatment.[20] A literature review by *Hou et al*., indicated that prognosis is poor or hopeless for deeper grooves that terminate further apically on the root. It was suggested that meticulous scaling and root planning, and flap operations, with or without odontoplasty, can maintain periodontal health in teeth with PRGs in motivated patients who are capable of maintaining effective plaque control.[21]

iii) Labial cervical vertical groove(LCVG)-

It starts on the cervical enamel and extends to the radicular surface and resembles a furrow and has also been described as notch. This furrow gradually grows deeper in apical direction and may occasionally run throughout the root surface. It is assumed that this malformation is a developmental anomaly in which an infolding of the enamel organ and Hertwigs epithelial root sheath creates a groove on the labial surface of permanent maxillary incisors.[18]

The presence of LCVG may exacerbate some clinical aberrations such as esthetic deficiency on gingival marginal contour, accumulation of plaque and consequently gingival pocket with bone loss, as well as failures in endodontic and periodontal treatment[18]. Most LCVGs are mild and often difficult to detect. However severe LCVG will result in more gingival irregularity. LCVG's with moderate grade of severity were found to be 5 times more susceptible to partial coverage of the gingival margin and 6 times more prone to irregular gingival coverage than LCVG with mild grade of severity. This and the increase in the sulcus depth in LCVG incisors are adverse predispositions for periodontal sequelae, calling for cautious oral hygiene maintenance[18].

Root grooves significantly enhance the loss of periodontal attachment. Such grooves may compromise the patients self care, reduce the operator's access for adequate subgingival scaling and jeopardize an otherwise successful periodontal treatment; therefore attention should be paid to the handling of the root grooves in prophylaxis and treatment of periodontal disease.[18, 20, 21]

Root Trunk Length:

Root trunk length is defined as area of the tooth extending from CEJ to the furcation. Therefore horizontal attachment loss leading to furcation invasion compromises the root trunk, resulting in the loss of one third of the total periodontal support.[22] The significance of root trunk is related to both prognosis and treatment of tooth. A molar with a short root trunk is more vulnerable to furcation involvement but has a better prognosis after treatment since less periodontal destruction has presumably occurred. Alternatively a furcation involved molar with a long root trunk and short roots may not be a candidate for root resection, since these teeth lose more periodontal support with furcation invasion.[19]

Furcation:

Furcation areas present some of the greatest challenge to the success of periodontal therapy. The anatomy of furcation favors retention of bacterial deposits and makes periodontal debridement as well as oral hygiene procedures difficult.[19]

Periodontal pockets in furcation areas of multi-rooted teeth offer particular difficulties with respect to debridement, due to limited accessibility through the furcation entrances as well as the complexity of the root anatomy. Progression of the destructive periodontitis lesions into the furcation region of the multi-rooted teeth is promoted to a large extent by the morphology of the root complex with its macroscopical and microscopical structures.[23]

Several morphologic factors related to the furcations and roots contribute to the etiology and compromised prognosis of the furcation involved teeth. These factors include root trunk length, furcation entrance width, root separation, root surface area, root concavities, cervical enamel projections, bifurcation ridges & enamel pearls.[24]

Bifurcation Ridges:

Bifurcation ridges are one of the contributing anatomical factors in the etiology and compromised prognosis of furcation involved teeth.

Two types of bifurcation ridges have been described.[19]

I) Intermediate
ii) Buccal / lingual ridges

Intermediate bifurcation ridges connect the mesial and distal roots and are

composed primarily of cementum. Buccal and lingual ridges are composed primarily of dentin with overlying thin layers of cementum.[2]

A study was conducted by *Hou et al*. to investigate the correlation of intermediate bifurcation ridges and CEP with furcation involvement in 87 furcally involved mandibular molars. Their results indicated that 63.2% of molars with furcation involvement had CEP's & intermediate bifurcation ridge with mandibular first molars having greater prevalence (67.9%) than mandibular 2nd molars (54.8%). A highly significant differences in clinical parameters of disease (pocket depth, CAL, plaque & gingival indices) was also found between mandibular 1st & 2nd molars with CEP's and intermediate bifurcation ridges compared to those without.[25]

In another study by *Gher ME et al*., the topography of furcation of maxillary & mandibular molars was studied and it was found that furcation areas demonstrated presence of numerous intermediate bifurcation ridges which present difficulties in proper debridement when the periodontal pocket reaches furcation entrance and runs into the furcation area.[16]

Table-1 summarizes the prevalence of important anatomical factors known to affect periodontal tissues

Tooth	Anatomic features	Prevalence
Maxillary incisors	Palatal grooves	0.79-21%
	98% of all grooves found in lateral incisors	
Maxillary first bicuspids	Root trunk length; avg 4-14.6mm	
	Furcal concavity on palatal aspect of buccal root	62%
	Mesial root concavities	100%
	Furcation entrance diameter <0.75mm	57%
Maxillary molars	Furcation entrance diameter <0.75mm	63%
	Root trunk length; averages	
	Mesial:3.5-4.2mm	
	Buccal:4.0-4.8mm	
	Distal:3.3mm	
	Cervical enamel projections	32.6%
Mandibular molars	Furcation entrance diameter <0.75mm	50%
	Root trunk length; averages	
	Buccal:2.4-3.14mm	
	Lingual:2.5-4.17mm	
	Cervical enamel projections	
	First molars	80.4%
	Second molar	48.4%
	Bifurcation ridges	65.5-76%

Cervical enamel projections:
Cervical enamel projections are ectopic deposits of enamel apical to the level of normal cemento-enamel junction, which may have tapering form and extend into the root furcation areas.[1] Cervical enamel projections are classified , using CEJ as a landmark;

Grade I - Short but distinct change in contour of CEJ extending towards the furcation.
Grade II - CEP approaches the furcation without making contract with it.
Grade III - CEP extends into the furcation.[26]

Strong association have been shown for the presence of CEP and furcation involvement based on cross sectional evaluation of extracted teeth, in human skulls and human subject.[26,27,28] Examination of 5000 extracted molars of human subjects showed a positive correlation between enamel projection and furcation involvement.[29]

A clinical study was conducted where total of 78 individuals aged 21-61 years with furcation involvement were examined for the presence of CEP's. It was found that 67.9% of the 78 individuals had CEP's. The prevalence of CEP's in molars with and without furcation involvements were 82.5% and 17.5% respectively. Statistical analysis revealed a significant difference between periodontal furcation involvement and presence of CEP's. Furcation involvements with CEP's were associated with poor oral hygiene as measured by GI and PI.[28]

In a consensus report on tooth related issues by *Blieden et al*., it was summarized that 15-25% of mandibular molars and 9-25% maxillary molars have CEP's and implicated them in periodontal destruction in furcation area.[2]

Although strong associations have been found, there are no prospective studies showing a cause and effect relationship between CEP's and development of disease at furcation.[28]

CEP's are probably related to the more rapid progression of pocket formation because of their anatomy and location. The enamel covering of the CEP would preclude an organic connective tissue attachment, instead a hemi-desmosomal attachment probably exists in the region of the CEP, and this seems less resistant to the breakdown by bacterial plaque. Once the breakdown occurs, rapid progression of the disease becomes more likely because the projection morphology of the cervical enamel allows the retention of the microbial plaque. In addition the region's inaccessibility to the cleansing and its proximity to the furcation could predispose to further furcation invasion. Whether a cause and effect relationship exists or not, requires more studies.[1]

Enamel Pearls:
In a review, it has been suggested that enamel pearls may have same clinical implications as cervical enamel

projections in regards to the possible predisposition to certain types of osseous defects. It has been postulated that fibers of the periodontal ligament could have no true attachment in the areas of enamel pearl. The presence of enamel pearl on the root surface is more significant in those cases in which they are connected by cemento-enamel projections to cervical enamel, rather than separated from the crown by epithelial attachment and a wide zone of healthy cementum and periodontal ligament. Enamel pearls and cervical enamel projections can occur on the same teeth and when they do, can be contiguous with each other.

Root concavities:

Root concavities are a significant feature of root configuration. The concavities can vary from shallow flutings, as seen on the mesial and distal surfaces of the canines, to deep developmental grooves on the mesial surface of maxillary first premolars. These concavities increase the attachment area and produce a root shape that is resistant to torquing forces. Conversely, concavities can act as predisposing factors in the disease process by providing a safe haven for bacterial plaque and by complication oral hygiene procedures. The concavities, which are limited mainly to the proximal surfaces, are generally inaccessible for cleaning with routine oral hygiene procedures. Interproximal cleaning devices, although potentially more effective than brushing, are time consuming and only partially successful in removing bacterial plaque. This may discourage long term compliance by patients in maintaining proper oral hygiene.[16]

A literature review by Bower RC et al. concluded that these root concavities and divergences make it unlikely that adequate root preparation by root planning can be achieved and straight and rigid cleaning devices (floss & wood points) are unlikely to remove all plaque.[30] The cementum formed in the concavity, especially the more porous cellular cementum, is likely to form a reservoir for endotoxin on the periodontally involved root surface, rendering it biologically unacceptable for attachment or approximation of soft tissues. These concave surfaces make both plaque removal and various periodontal therapeutic procedures difficult.[31]

Root proximity:

Proximity of the roots of adjacent teeth is widely held as a risk factor for development of periodontal disease.

Root proximity may present an impediment to self-performed or professionally applied plaque removal, and in this way lead to enhanced gingival inflammation. Because the volume of connective tissue and bone is reduced in areas where the tooth roots are in close proximity, any inflammation that occurs at these sites is thought to easily destroy this tissue. There is no scientific evidence to support this contention, however. In fact, a long-term study of root proximity after orthodontic treatment showed no predisposition to more rapid periodontal breakdown.

Summary:

Periodontitis is a multifactorial infectious disease. Over the last century numerous investigators have attempted to define etiologic agents of the diseases and it is not clear that specific bacterial pathogens are the primary etiologic agents. Several conditions exist around teeth that may predispose the periodontium to disease. Diverse morphologic tooth deformities found on tooth/root surface such as cervical enamel projections, enamel pearls, molar root concavities, intermediate bifurcation ridges, architecture of furcation entrances, root fusions may adversely influence the course and the management of periodontal disease. Position of the tooth in arch and mucogingival deformities can also enhance bacterial accumulation or allow ingress of bacteria into periodontium. The primary goal of periodontal therapy is to produce an environment that is conducive to oral health. Local etiologic factor may prevent removal of supragingival plaque and may even contribute to destruction of periodontal tissues. Thus it is crucial to be able to recognize and when possible, eliminate any plaque retentive factors that could contribute to disease progression. Such factors compromise patient's self care, reduce operators access for subgingival scaling and jeopardizes otherwise successful periodontal treatment. In Consensus report by World Workshop in Clinical Periodontics (1999) it was rightly stated that "tooth related conditions are not separate disease entities". But they may serve as localized predisposing and/or modifying factors in the onset or progression of plaque induced gingival disease and periodontitis.

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Information For Authors

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