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Review Article

Gingival Biotype and Gingival Bioform: Determining Factors for Periodontal Disease Progression and Treatment Outcome

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Abstract

Oral tissues show different response and behavior to different oral diseases and treatment procedures. A clinically healthy periodontium has shown to have a varied phenotypic appearance differing from subject to subject. Several researchers, on-lookers, academicians, and clinicians have tried to study in their ways about these different gingival entities. Apart from, various local factors, host response and individual host characteristics have been seen to play a central role. Gingival biotype and gingival bioform determined by factors such as crown width, crown length, gingival width, papilla height, gingival thickness, and significantly influence the disease progression as well as treatment outcome. This review describes and highlights these gingival parameters and the factors affecting it.

Key words: Bioform, Biotype, Gingival width, Papilla height, Parameters

INTRODUCTION

Research has always played a key role in the field of periodontics. With the ever increasing scientific knowledge about smaller and smaller tissues, several new aspects of etiology, pathogenesis and also the related treatment options have come up and broadened the horizon of the existing periodontology. Hence, keeping up with this research orientation, the current ongoing subject of interest is the base of periodontium - The human gingiva.

Now, since long, the explanations for the occurrences of a particular periodontal disease have been largely influenced by paradigms that reflected the understanding of the disease during that time. But today, with the improvement of our knowledge toward the pathogenesis of periodontal diseases, apart from the presence of local factors, host response is considered to be one of the most important aspects to influence its initiation and progression.[1] This is evident from the observation that same quantity and quality of plaque exhibits differences in severity of periodontal diseases in different subjects.[1]

This observation has led to speculate to other putative (associated) reasons to find out the different responses and behavior of the tissues during disease and treatment. The researchers concentrated to explain this on the basis of different systemic and local factors. Sometimes, we get progressive periodontal pockets and at another time we observe recession. Is the behavior of the local tissues responsible for this different response? In this aspect, the anatomical and histological characteristics have been analyzed extensively, and the researchers have found difference in the biological behavior, and its configuration at large, and it is speculated that this difference is responsible for different tissue responses.[2]

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HISTORICAL BACKGROUND

A clinically healthy periodontium has shown to have a varied phenotypic appearance differing from subject to subject.[3]

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Several researchers, on-lookers, academicians, and clinicians have tried to study in their ways about these different gingival entities. Like in 1969, Ochsenbein and Ross suggested the occurrence of two main variants of gingival morphology:[4]

- Scalloped and thin gingiva
- Flat and thick gingiva.

While some researchers attributed this difference to the difference in shape and form of the teeth,[5,6] there were others who proposed that it was the contour of the underlying alveolar bone which ultimately determined the gingival contour.[4] As they served to illustrate the existence of markedly different periodontal entities, they were called as "gingival biotypes."[7]

Now, as these observations gained momentum and caught the eye of the fellow researchers, different terminologies came up describing these varied morphologies. The term "periodontal biotype"[8] was introduced by Siebert and Lindhe to categorize the gingiva into "thick-flat" and "thin-scalloped biotypes. In 1997, Muller H coined the term "gingival" or "periodontal phenotype" to address the common clinical observations of the great variation in the thickness and width of facial keratinized tissue.[9] With the advent of dental implants, the term "gingival biotype" or "morphotype" was renamed to "soft tissue biotype" to encompass tissue around both teeth and implants.[10]

GINGIVAL BIOTYPE

The oral mucosa of every individual is divided into two soft tissue entities: Gingiva and alveolar mucosa. Both these tissues are characteristically different clinically as well as histologically.[11] Before, it was known that it was the proportion of these two tissues that predisposed an individual to the risk of developing mucogingival problems,[12] but now, with the deeper knowledge about the existence of variations even within these tissues, it is clear that along with their proportions, the difference in the morphologic and histologic characteristics of gingiva itself increased the likelihood of mucogingival deformities, and such variations are termed as thick and thin biotypes.[13]

The term gingival biotype[14-17] has been used to describe the thickness of the gingiva in the faciopalatal dimension and it is a genetically determined trait.[18,19] In general, there are two variants of gingival biotype which are found to exist as follows:

- Thick biotype (prevalence: 85%)
- Thin biotype (prevalence: 15%).

Along with this, there are also few other cases which have overlapping features of both thick and thin types in different areas of the arches.[3]

Thick biotype, as the name suggests, is characterized by thick gingival tissue and is generally found to be most commonly related with good periodontal health. Such a tissue is quite dense in appearance with a sufficient zone of attached gingiva. There are ample of evidence which suggest that when subjectively determined, a thick tissue resists trauma and subsequent recession, enables tissue manipulation, promotes creeping attachment, improves implant aesthetics, exhibits less clinical inflammation, and renders predictable surgical procedures.[20-26] Now, the factors that are responsible for these characteristics are as follows:

1. The presence of a high volume of extracellular matrix and collagen which permits the tissue to withstand collapse and contraction.
2. An increase in the layers of epithelial keratinization, which deflects physical damage and microbial ingress.
3. An increase in vascularity. The great perfusion enhances oxygenation, clearance of toxic products, immune response, and growth-factor migration, thereby boosting healing.

On the other hand, thin biotype as the name suggests is characterized by thin gingival tissue making it delicate and almost translucent in appearance. Such a tissue appears friable, usually, having a minimal zone of attachment. The soft tissue is highly accentuated and often suggestive of thin or minimal bone over the roots labially, and evidence are there showing that the thin gingival tissue is less resistant to any inflammatory/traumatic/surgical insult and so usually exhibits pathological changes like the gingival recession.[14,16,20,27-32] Furthermore, they are frequently characterized by osseous defects like fenestration and dehiscence.[33]

As seen in the description above, the different gingival biotypes respond differently to inflammation, restorative procedures, trauma, and parafunctional habits.[19] Even the tissue response to different treatments varies.[4] Therefore, an accurate diagnosis of gingival tissue biotype is of the utmost importance in deciding an appropriate treatment plan and achieving a predictable esthetic outcome.

GINGIVAL BIOFORM

Clinically, great variation exists between humans with respect to morphological characteristics of the periodontium, and as seen above, two basic "biotypes" of gingival architecture, the "scalloped-thin" and the "flat-thick," were proposed to exist. Thick and thin refers to the dimension of the gingival tissue in the faciopalatal dimension, whereas the terms "scalloped" and "flat" are referred as "Gingival Bioform."

Gingival bioform refers to different scallop morphologies of the marginal and interdental gingiva, and as such three different gingival scallop morphologies are seen:

- Low
- Normal
- High.

They are found to be associated with different tooth forms:

- Circular/square tooth form shows low/shallow scallop
- Triangular tooth form shows pronounced scallop.

This shows the subjective assessment of the gingival bioforms. Objectively, a measurement of 4 mm classifies the scallop morphologies. According to this, if the distance between the interproximal gingival peaks (most coronal) and the mid-facial free gingival margin peaks (most apical) is 4 mm - normal scallop.
If distance is <4 mm - Low or shallow scallop.
If distance is >4 mm - High or pronounced scallop.

Hence, the scalloped gingiva can be categorized as high, normal, flat/low.[34] As known, in a healthy periodontium, the alveolar crest is positioned approximately 2 mm apical to the cementoenamel junction (CEJ) and mimics or follows the scallop of CEJ.[35] In the normal and high scalloped gingival form, there is more tissue coronal to the interproximal bone than the facial bone.[35]

Supporting this in a 1994 article, Kois[34] examined crestal bone levels and classified them as normal (crestal bone level is 3 mm apical to CEJ), high (crestal bone level is <3 mm apical to CEJ), and low (crestal bone level is >3 mm apical to CEJ) as found in patients with recession.[34]

The "scalloped-thin" gingiva has been suggested to be associated with as follows:

1. Tapered crown form
2. Subtle cervical convexity
3. Minute proximal contact areas located near the incisal edge of the tooth.

The "flat-thick" gingiva, on the other hand, corresponds to a tooth with:

1. Squared facial form
2. Distinct cervical convexity
3. Relatively large, more apically located contact areas.

As discussed, the severity of symptoms associated with plaque-induced periodontal disease might vary according to different gingival biotypes. Thus, a deep periodontal pocket might exist in individuals with a "flat-thick" appearance while gingival recession occurs in individuals with a "scalloped-thin" appearance in response to plaque-associated inflammation.[8,27]

FACTORS AFFECTING GINGIVAL BIOTYPE AND GINGIVAL BIOFORM

The different parameters which affect the two morphologic types (biotype and bioform) are gingival complex, tooth morphology, contact points, hard and soft tissue considerations, gingival bioform, and biotype. Hence, a clinician's knowledge of anatomy, form, and function of the dentition is of paramount importance in achieving optimal treatment outcomes.

It has long been known that clinical appearance of healthy marginal periodontium differs from subject to subject and even among different tooth types. It has been suggested that many features are directly genetically determined, whereas other morphologic characteristics of the periodontium seem to be influenced by tooth size, shape and position, and biological phenomena such as growth or ageing.[36,37]

Gingival thickness affects the biotype of the gingiva, whereas, crown width (CL): Crown length (CW), papilla height, and gingival width are responsible for determining the gingival bioform.

CW: CL

Ochsenbein and Ross first classified the gingival anatomy as either "flat" or "pronounced scalloped," with the suggestion that flat gingiva was related to a square tooth form and pronounced scalloped gingiva was related to a tapered tooth form.[4] Now, what determined this form of tooth was the ratio between the CW and CL of a tooth. There was a tendency for a flat gingival architecture to have a lower tooth height-to-width ratio, while a scalloped gingival architecture was associated with a higher tooth height-to-width ratio, but the differences were not statistically significant in every study.[38,39]

It has been observed that individuals having a tapered tooth form usually have a thin, scalloped gingival architecture, and clinically; this has been associated with an increased susceptibility to recession. This theory was further supported by studies demonstrating that central incisors with a narrow crown form had a greater prevalence of recession than incisors with a wide, square form.[3,27,40] However, Eger *et al.*, on the other hand, failed to observe a meaningful influence of CW/CL ratio on gingival thickness.[41] Furthermore, a study by Cook *et al.*, who evaluated various gingival parameters in patients having different gingival biotypes did not document any significant differences between tissue biotypes and crown height to width ration, age, sex and gingival margin position.[38]

GINGIVAL WIDTH

The keratinized portion of the gingiva on the facial aspect of the teeth extends from the margin of the soft tissue to the mucogingival junction. Not all of the gingiva covering the tooth is attached. The attached portion of the gingiva is clinically defined as the distance from depression below the projection on the external surface of the gingival sulcus to the mucogingival junction.

There is no minimum width of keratinized or attached gingival tissue necessary to maintain health, provided plaque control is adequate; however, sites with narrow keratinized gingiva have been associated with increased recession when exposed to mechanical trauma or poor oral hygiene,[42,43] and also, it has been suggested that a wide zone of keratinized and attached gingiva is more desirable than a narrow zone or a total lack of such a zone, because a wide zone would better withstand gingival inflammation, trauma from mastication, tooth brushing and forces from muscle pull and orthodontic procedures.

Many clinicians believe that a flat gingival architecture is associated with a wider zone of keratinized tissue, while a scalloped architecture is associated with a narrower zone, and so relatively, a patient with a thin gingival biotype displays a narrower zone of keratinized tissue than a patient with a thick/average gingival biotype. Olsson *et al.* (1993) reported significantly wider keratinized tissue at facial aspects, a lower papilla height, a higher gingival angle of the crown, but no significant difference in gingival thickness in short-wide as compared with long-narrow central incisors.[40]

PAPILLA HEIGHT

In contemporary dentistry, there has been an increasing demand for improved aesthetics by both dentists and patients. The existence of the interproximal papilla is pivotal to an esthetic gingival form[15,16] which is determined by the form and position of the clinical crown, interproximal contact point, and form of embrasure space.[44]

The interdental papilla occupies the interdental or embrasure space and acts as a barrier to protect underlying periodontal structures[45] and also plays an esthetic role.[46] The distance from the contact point to the interproximal alveolar crest has been identified as a critical factor in the presence of a complete papilla, with nearly 100% of papillae filling the gingival embrasure completely if contact point-bone crest distance is ≤5 mm.[47]

Few studies have examined factors contributing to the presence and absence of dental papillae. Most focused on the influence of crestal bone height and/or interproximal distance. Many other factors that might influence papillary appearance such as tooth form/shape, gingival thickness and keratinized gingiva/attached gingiva width, distance from the contact point to the bone crest, inter-radicular distance, size of the embrasure space, have never been fully examined, but these have been listed to be relevant factors.[1-4,40]

As mentioned above, the morphological properties of the periodontal tissues are related to the shape and appearance of the teeth,[5,6] which is generally divided into triangular, oval, and rectangular types. Chen *et al.*[48] suggested that there is a high likelihood that the fidelity of the interproximal papilla increases as the tooth shape becomes more rectangular. Kois[20] and Shigeno[49] further claimed that a rectangular tooth shape has a longer contact area and requires less of the interproximal papilla to fill up the embrasure space.

There have also been reports showing a positive correlation between gingival thickness and papilla fill. Decrease in papilla height is observed with thin biotype. Limited blood supply[50] is believed to be one of the major reasons why papilla preservation and regeneration are difficult. Thicker tissue may resist collapse and contraction due to increased vascularity and extracellular matrix volume.[51] In addition, thicker keratinized gingival epithelium may be more resistant to physical damage and bacterial ingress. Therefore, thick gingival biotype has been considered more favorable for achieving optimal aesthetics.

Hence, it has been concluded from several studies that the appearance of the gingival papilla is significantly associated with age, tooth form/shape, proximal contact length, crestal bone height and interproximal gingival thickness, and the following clinical conditions were found to favor a gingival papilla that fills the interproximal embrasure space:[52,53]

1. Young subject
2. CW/CL ≥0.87
3. Long proximal contact ≥2.8 mm
4. Bone crest-contact point ≤5 mm
5. Thick interproximal gingival tissue ≥1.5 mm.

GINGIVAL THICKNESS

It has been suggested that different gingival entities have different tooth shapes.[8,27] Many studies have examined the correlation between the tooth shape and gingival biotype. Sanavi *et al.*[54] claimed that the thick and flat periodontal tissues have a rectangular tooth shape, and the thin scallop-shaped periodontal tissues have a triangular tooth shape.

Olsson and Lindhe[40] reported that long and narrow crowns have thin periodontal tissues and a high likelihood of having gingival recession compared to the thick gingival biotype, suggesting a relationship between the tooth shape and gingival biotype. On the other hand, Olsson *et al*.[3] reported no relationship between the tooth shape and gingival thickness according to the CW and CL.

Studies by Morris,[5] Olsson and Lindhe[3] documented that individuals with tapered crowns have a thinner biotype, making them more susceptible to gingival recession. Chow and Wang[55] in their review article stated the presence of long narrow form with thin gingival tissue. Seo *et al*.[56] in their study did not find any statistically significant differences between the longer and shorter teeth in relation to gingival biotypes. Weisgold *et al*.[27] considered long tapering teeth more susceptible to gingival recession while square teeth appeared to have a greater zone of gingiva that was more resistant to gingival recession.

AGE AND SEX

The thicker biotype is more prevalent in male population while the female population consists of thin, scalloped gingival biotype.[57] On comparing, the prevalence of gingival biotypes between different age groups, the thick flat biotype is seen in younger individuals while older age group shows thin scalloped gingival biotype.[58] Vandana and Savitha[58] in their study on gingival thickness showed thicker gingiva in younger age group and stated that decrease in keratinization and changes in oral epithelium may be the contributing factors. Chang[59] in his study stated that an inverse relationship has been found to be existing between papilla height and age. Sanavi *et al*.[54] in their review article described that the inter-root bone is more in the thinner biotype. This, in turn, can cause more recession. They also stated that the interproximal papilla does not cover the spaces between two teeth in thinner biotype as compared to thick biotype. This could possibly relate to increased amount of recession and also the presence of thin biotype in older age group.[60] Chow *et al*.[28] also evaluated various factors associated with the appearance of gingival papillae and found significant associations with age and the crown form and gingival thickness. Olsson *et al*.[3,40] documented that the central incisors with narrow tooth form had greater amount of recession when compared to incisors with square form. With age, the interdental papilla recedes; this explains the greater frequency of thin biotype seen with older age group.[61]

Anterior teeth with narrow zones of attached gingiva are frequently encountered in children. Maynard and Ochsenbein[62] suggested that newly erupted permanent teeth with narrow attached gingiva may run a greater risk of gingival recession. The results of some cross-sectional studies in children, teenagers, and adults indicate that the width of attached gingiva increases with age. In the permanent dentition, the gingival problems are often noticed in the age when children are candidates for orthodontic treatment, and considerable attention has been focused on various therapeutic measures.

CONCLUSION

It is evident from the above-reported literature that the shape, size, form of the tooth and the surrounding gingiva is of paramount importance for the causation and progression of disease and henceforth for the diagnosis and subsequent inter- and multi-disciplinary treatment approach. This knowledge of the tissue behavior thus helps in the right selection of the surgical/restorative/orthodontic treatment procedure for the patient.

REFERENCES

1. Haake SK, Etiology of periodontal diseases. In: Newman MG, Takei HH, Carranza FA, editors. Carranza's Clinical Periodontology. 9th ed. United States of America: W.B. Saunders Co; 2002. p. 95.
2. Hwang D, Wang HL. Flap thickness as a predictor of root coverage: A systematic review. J Periodontol 2006;77:1625-34.
3. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. J Clin Periodontol 1991;18:78-82.
4. Ochsenbein C, Ross S. A reevaluation of osseous surgery. Dent Clin North Am 1969;13:87-102.
5. Morris ML. The position of the margin of the gingiva. Oral Surg Oral Med Oral Pathol 1958;11:969-84.
6. Wheeler RC. Complete crown form and the periodontium. J Prosthet Dent 1961;11:722-34.
7. Eghbali A, De Rouck T, De Bruyn H, Cosyn J. The gingival biotype assessed by experienced and inexperienced clinicians. J Clin Periodontol 2009;36:958-63.
8. Seibert JL, Lindhe J. Esthetics and periodontal therapy. In: Lindhe J, editor. Textbook of Clinical Periodontology. 2nd ed. Copenhangen, Denmark: Munksgaard; 1989. p. 477-514.
9. Müller HP, Eger T. Gingival phenotypes in young male adults. J Clin Periodontol 1997;24:65-71.
10. Sammut E. Soft tissue biotype and its implications-Dental Clinical Articles-PPD Magazine.htm. [Last accessed on 2013 May 15].
11. Lozdan J, Squier CA. The histology of the muco-gingival junction. J Periodontal Res 1969;4:83-93.
12. Lang NP, Löe H. The relationship between the width of keratinized gingiva and gingival health. J Periodontol 1972;43:623-7.
13. Wennström JL, Stokland BL, Nyman S, Thilander B. Periodontal tissue response to orthodontic movement of teeth with infrabony pockets. Am J Orthod Dentofacial Orthop 1993;103:313-9.
14. Kan JY, Rungcharassaeng K, Morimoto T, Lozada J. Facial gingival tissue stability after connective tissue graft with single immediate tooth replacement in the esthetic zone: Consecutive case report. J Oral Maxillofac Surg 2009;67:40-8.
15. Kan JY, Rungcharassaeng K. Site development for anterior single implant esthetics: The dentulous site. Compend Contin Educ Dent 2001;22:221-6, 228, 230-1.
16. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73-80.
17. De Rouck T, Eghbali R, Collys K, De Bruyn H, Cosyn J. The gingival

biotype revisited: Transparency of the periodontal probe through the gingival margin as a method to discriminate thin from thick gingiva. J Clin Periodontol 2009;36:428-33.
18. Melsen B, Allais D. Factors of importance for the development of dehiscences during labial movement of mandibular incisors: A retrospective study of adult orthodontic patients. Am J Orthod Dentofacial Orthop 2005;127:552-61.
19. Kao RT, Fagan MC, Conte GJ. Thick vs. Thin gingival biotypes: A key determinant in treatment planning for dental implants. J Calif Dent Assoc 2008;36:193-8.
20. Kois JC. Predictable single-tooth peri-implant esthetics: Five diagnostic keys. Compend Contin Educ Dent 2004;25:895-900.
21. Müller HP, Heinecke A, Schaller N, Eger T. Masticatory mucosa in subjects with different periodontal phenotypes. J Clin Periodontol 2000;27:621-6.
22. Pontoriero R, Carnevale G. Surgical crown lengthening: A 12-month clinical wound healing study. J Periodontol 2001;72:841-8.
23. Romeo E, Lops D, Rossi A, Storelli S, Rozza R, Chiapasco M. Surgical and prosthetic management of interproximal region with single-implant restorations: 1-year prospective study. J Periodontol 2008;79:1048-55.
24. Nagaraj KR, Savadi RC, Savadi AR, Prashanth Reddy GT, Srilakshmi J, Dayalan M, *et al*. Gingival biotype - Prosthodontic perspective. J Indian Prosthodont Soc 2010;10:27-30.
25. Chung DM, Oh TJ, Shotwell JL, Misch CE, Wang HL. Significance of keratinized mucosa in maintenance of dental implants with different surfaces. J Periodontol 2006;77:1410-20.
26. Jivraj S, Chee W. Treatment planning of implants in the aesthetic zone. Br Dent J 2006;201:77-89.
27. Weisgold AS. Contours of the full crown restoration. Alpha Omegan 1977;70:77-89.
28. Claffey N, Shanley D. Relationship of gingival thickness and bleeding to loss of probing attachment in shallow sites following nonsurgical periodontal therapy. J Clin Periodontol 1986;13:654-7.
29. Egelberg J. The blood vessels of the dento-gingival junction. J Periodontal Res 1966;1:163-79.
30. Kindlová M. Development of vessels in the marginal periodontium in rats. J Dent Res 1968;47:507.
31. Kindlová M. The development of the vascular bed of the marginal periodontium. J Periodontal Res 1970;5:135-40.
32. Baldi C, Pini-Prato G, Pagliaro U, Niero M, Saletta D, Muzzi L, *et al.* Coronally advanced flap procedure for root coverage. Is flap thickness a relevant predictor to achieve root coverage? A 19-case series. J Periodontol 1999;70:1077-84.
33. Alhulaimi HA, Awartani FA. Periodontium biotype modification prior to an orthodontic therapy: Case report. King Saud Univ J Dent Sci 2013;4:91-4.
34. Kois JC. Altering gingival levels: The restorative connection. Part. 1: Biologic variables. J Esthet Dent 1994;6:3-7.
35. Newman MG. The normal periodontium. In: Newman MG, Takei HH, Carranza FA, editors. Carranza's Clinical Periodontology. 9th ed. United States of America: W.B. Saunders Co; 2002. p. 15-62.
36. Schluger S, Yuodelis R, Page RC, Johnson RH. Periodontal Diseases. 3rd ed. Philadelphia, PA: Lea and Langer; 1990. p. 561.
37. Ohyama H, Nagai S, Tokutomi H, Ferguson M. Recreating an esthetic smile: A multidisciplinary approach. Int J Periodontics Restorative Dent 2007;27:61-9.
38. Chow YC, Eber RM, Tsao YP, Shotwell JL, Wang HL. Factors associated with the appearance of gingival papillae. J Clin Periodontol 2010;37:719-27.
39. Cook DR, Mealey BL, Verrett RG, Mills MP, Noujeim ME, Lasho DJ, *et al.* Relationship between clinical periodontal biotype and labial plate thickness: An *in vivo* study. Int J Periodontics Restorative Dent 2011;31:345-54.
40. Gobbato L, Tsukiyama T, Levi PA Jr, Griffin TJ, Weisgold AS. Analysis of the shapes of maxillary central incisors in a Caucasian population. Int J Periodontics Restorative Dent 2012;32:69-78.
41. Eger T, Müller HP, Heinecke A. Ultrasonic determination of gingival thickness. Subject variation and influence of tooth type and clinical features. J Clin Periodontol 1996;23:839-45.
42. Wennström J, Lindhe J. Role of attached gingiva for maintenance of periodontal health. Healing following excisional and grafting procedures in dogs. J Clin Periodontol 1983;10:206-21.
43. Ericsson I, Lindhe J. Recession in sites with inadequate width of the keratinized gingiva. An experimental study in the dog. J Clin Periodontol 1984;11:95-103.
44. Olsson M, Lindhe J, Marinello CP. On the relationship between crown form and clinical features of the gingiva in adolescents. J Clin Periodontol 1993;20:570-7.
45. Zetu L, Wang HL. Management of inter-dental/inter-implant papilla. J Clin Periodontol 2005;32:831-9.
46. Hassell TM. Tissues and cells of the periodontium. Periodontal 2000 1993;3:9-38.
47. Takei H, Yamada H, Hau T. Maxillary anterior esthetics. Preservation of the interdental papilla. Dent Clin North Am 1989;33:263-73.
48. Tarnow DP, Magner AW, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. J Periodontol 1992;63:995-6.
49. Chen MC, Liao YF, Chan CP, Ku YC, Pan WL, Tu YK. Factors influencing the presence of interproximal dental papillae between maxillary anterior teeth. J Periodontol 2010;81:318-24.
50. Shigeno K, editor. Understand periodontol plastic surgery. Illustrated Periodontal Plastic Surgery. Toyko: Ishiyaku Publishers; 2005. p. 290-331.
51. Fu JH, Yeh CY, Chan HL, Tatarakis N, Leong DJ, Wang HL. Tissue biotype and its relation to the underlying bone morphology. J Periodontol 2010;81:569-74.
52. Kennedy JE. Effect of inflammation on collateral circulation of the gingiva. J Periodontal Res 1974;9:147-52.
53. Kim JH, Cho YJ, Lee JY, Kim SJ, Choi JI. An analysis on the factors responsible for relative position of interproximal papilla in healthy subjects. J Periodontal Implant Sci 2013;43:160-7.
54. Sanavi F, Weisgold AS, Rose LF. Biologic width and its relation to periodontal biotypes. J Esthet Dent 1998;10:157-63.
55. Chow YC, Wang HL. Factors and techniques influencing peri-implant papillae. Implant Dent 2010;19:208-19.
56. Seo H, Chung C, Lim S, Hong K. Radiographic evaluation of alveolar bone profile of maxillary anterior teeth in Korean young adults. J Korean Acad Periodontol 2006;36:461-71.
57. Vinaya B, Sonali S. Prevalence of different gingival biotypes in individuals with varying forms of maxillary central incisors: A survey. J Dent Implants 2013;3:116-21.
58. Vandana KL, Savitha B. Thickness of gingiva in association with age, gender and dental arch location. J Clin Periodontol 2005;32:828-30.
59. Chang LC. The association between embrasure morphology and central papilla recession. J Clin Periodontol 2007;34:432-6.
60. Ko-Kimura N, Kimura-Hayashi M, Yamaguchi M, Ikeda T, Meguro D, Kanekawa M, *et al.* Some factors associated with open gingival embrasures following orthodontic treatment. Aust Orthod J 2003;19:19-24.
61. Wara-aswapati N, Pitiphat W, Chandrapho N, Rattanayatikul C, Karimbux N. Thickness of palatal masticatory mucosa associated with age. J Periodontol 2001;72:1407-12.
62. Maynard JG Jr, Ochsenbein C. Mucogingival problems, prevalence and therapy in children. J Periodontol 1975;46:543-52.

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