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Review Article

Gingival Biotype- General Aspects and Its Clinical Applications

Aarti Dhawle[1], Vishakha Patil[2], Abdul Aziz[3]

[1]PG student, [2]Professor, Department of Periodontology, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Pune, Maharashtra, [3]Private Practitioner, Consultant Periodontist

ABSTRACT

The gingival biotype is not only significant factor influencing aesthetic treatment outcome such as dental implant placement, periodontal surgeries such as root coverage and ridge augmentation procedures but also on restorative and orthodontic therapy. They exhibit different pathological responses when subjected to inflammatory, traumatic or surgical insults as gingival biotypes have different gingival and osseous architectures. Therefore identification of the gingival biotype is important in day to day clinical practice as these pathological responses dictate different treatment modalities. Gingival biotype is commonly neglected factor which affects success and failure of the treatment. This review depicts general aspects of gingival biotypes, the various classifications, methods of assessment and clinical considerations of different tissue biotypes.

Key words: Gingival biotype, Gingival bioform, Clinical importance, Periodontal therapy.

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Corresponding author: Dr. Aarti Dhawle, PG student, Department of Periodontology, Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Pune, Maharashtra

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INTRODUCTION

Periodontium is the functional unit of the tissues supporting the tooth. It is comprised of four principal components namely the gingiva, the periodontal ligament, the alveolar bone and the cementum. Each of these components is distinct in its location, tissue architecture, biochemical composition and yet, they function together as a single unit. In health, gingiva is the only component of the periodontium which is exposed to the external environment. Along with the covering of the hard palate, it constitutes the masticatory mucosa, a component of oral mucosa, the others being the superficial mucosa (covers the dorsum of the tongue) and the lining mucosa.[1]

A well scalloped gingival line at the cement-enamel junction (CEJ) of the teeth forms one of the pillars of a beautiful smile. In the aesthetics dentistry, it is of paramount importance that a clinician should be well aware of all the factors that may influence the final aesthetic outcome of a treatment. One such factor that dentist should consider before starting any periodontal, prosthetic and restorative procedure is the "Gingival biotype." which is known to influence the indications and outcomes of various therapies routinely performed in a dental clinic.

The term ''gingival phenotype'' is used to address the common clinical observation of great variation in the thickness and width of facial keratinized tissue.[2,3] Gingival biotype[4,5,6] is described as the thickness of the gingiva in the faciopalatal/ faciolingual dimension i.e. it mainly refers to the quality of the soft tissue profile surrounding the teeth. Periodontal attachment loss and marginal tissue recession are common disadvantages of reduced gingival thickness which is a major concern for periodontal disease progression.[7]

Historical background

The term "gingival or periodontal phenotype" was coined by Muller H.to address the common clinical observations of the great variation in the thickness and width of facial keratinized tissue.[8,9]The term "periodontal biotype" was used later by Seibert & Lindhe to describe the thickness of the gingiva in a bucco-lingual dimension (thick or thin).[10,11]The term "gingival biotype" or "morphotype" was renamed to "soft tissue biotype" to surround the tissue around both teeth and implants, when dental implants were introduced in dentistry.[12]

Classification

A clinically healthy periodontium has shown to have following varied phenotypic appearance differing from subject to subject.[13]

I. Hirschfield in 1923 observed a thin alveolar contour and made the assumption that a thin bony contour was probably accompanied by thin gingival form.[14]

II. Ochsenbien and Ross in 1969 indicated that, gingival biotypes are of two types -they are *scalloped*and *thin*or *flat* and *thick* gingiva. They proposed that the contour of the gingiva closely followed the contour of the underlying bone.[15](Figure 1 & figure 2)

TABLE 1: FEATURES OF THICK AND FLAT GINGIVAL BIOTYPE & THIN AND SCALLOPED GINGIVAL BIOTYPE[16]

Thick and flat biotype	Thin and scalloped biotype
Thick heavy periodontium	Delicate thin periodontium
Flat gingival contour	Heavy scalloped gingival tissue
Gingival margins usually coronal to the cementoenamel junction	Usually slight gingival recession
Thick, flat osseous contour	Highly scalloped osseous contour
Wide zone of keratinized gingiva	Minimum zone of keratinized gingiva
Broad apical contact areas	Small incisal contact areas
Square anatomic crowns	Triangular anatomic crowns
Insult results in pocket depth or redundant tissue	Insult results in recession
Bulbous convexities in cervical third of facial surface	Subtle diminutive convexities in cervical third of the facial surface

Figure 1: Clinical presentation of thin gingival biotype

Figure 2: Clinical presentation of thick gingival biotype

III. In 1977,Weissgold emphasized that the form and function are related and therefore the terms thin scalloped and thick flattype was introduced.[17]

IV. Later in 1986 Claffey and Shanley defined the thin tissue biotype as a gingivalthickness of ≤1.5 mm, and the thick tissue biotype was referred to as having a tissue thickness ≥2 mm (measurements of 1.6 to 1.9 mm were not accounted for)[18]

V. Seibert and Lindhe in 1989 categorized it into "thick-flat" and "thin- scalloped" biotypes.[10]

VI. In 1996, Kois suggested a classification system involving the relationship between cementoenamel junction and the crest of the bone.

a) Normal crest: alveolar crest is 3mm apical to the cementoenamel junction (85% of the population).
b) High crest: alveolar crest is < 3 mm apical to the cementoenamel junction (2% of the population).
c) Low crest: alveolar crest is >3mm apical to the cementoenamel junction (13% of the population).

VII. Becker et al in 1997 [19] proposed following classification by measuring from the height of the bone interproximally to the height at the direct midfacial.

a) flat = 2.1 mm,
b) scalloped = 2.8 mm,
c) pronounced scalloped = 4.1 mm.

VIII. De Rouck et al in 2009[20]illustrated following gingival biotypes.

a) Occurred in one third of the study population and was prominent among females, was classified as having a thin gingival biotype, slender tooth form, narrow zone of keratinized tissue and a high gingival scallop.
b) Occurred in two thirds of the study population and was prominent among males, was classified as having a thick gingival biotype, quadratic tooth form, broad zone of keratinized tissue and a flat gingival margin.

Gingival Bioform[21]

Clinically, two basic "biotypes" of gingival architecture, "scalloped-thin" and "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 seen as:

a. Low
b. Normal
c. High.

Subjectively, circular/square tooth form shows low/shallow scallop & triangular tooth form shows pronounced scallop. Objectively, 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

<4 mm - low or shallow scallop
>4 mm - high or pronounced scallop

Hence, the scalloped gingiva can be categorized as high, normal, flat/low.[22]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. In the normal and high scalloped gingival form, there is more tissue coronal to the interproximal bone than the facial bone.[23]

Factors affecting the gingival biotype

Age

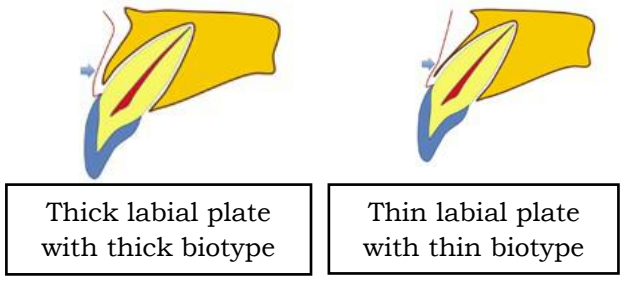
In general more prevalence of thicker gingival biotype has been found in younger age groups. Vandana and Savitain 2005 [24] in their study on gingival thickness showed that thicker gingiva in younger age group and stated that decrease in keratinisation and changes in oral epithelium may be the contributing factors. Chang in 2007[25]stated that an inverse relationship is found to be existing between papilla height and age. Olsson et alin 1991 [13]found that the interdental papilla recedes with increasing age; which explains the greater frequency of thin biotype seen with older age group.

Gender

According to Dr. Seba Abraham et al in 2015 [26]found that male population had thicker gingival biotype with more prevalence (74%) as compared to females. Females have more number of thin biotype (66%) while 34% have a thick biotype. De Rock et al in 2008 [20]and Muller et al in 1997[9]found similar results in which 1/3rd of the sample to be females with a thinner biotype and male participants had thicker gingiva to conceal the periodontal probe when compared to female.

Underlying Alveolar Bone[27]

The tissue biotype is mostly reflected by the thickness of underlying alveolar bone.In thick biotype the labial/buccal plate may be thick enough to accommodate a separate bundle bone around the tooth. In thin biotype the bone is usually very thin, resulting in the bundle bone and the labial/buccal plate being one and the same bit of bone. Dehiscence and fenestrations are usual findings in thin underlying bone.



Thick labial plate with thick biotype	Thin labial plate with thin biotype

Position of Teeth

The dimensions of the buccal gingiva may also be affected by the bucco–lingual position of the tooth within the alveolar process. A change of the tooth position in buccal direction results in reduced dimensions of the buccal gingiva, while an increase is observed following a lingual tooth movement.[28,29]

Tooth Form

Morphologic characteristics of the periodontium are related to the shape and form of the tooth. There are two main types of gingival anatomy i.e. flat and scalloped, identified as the bulky, slightly scalloped/flat marginal gingival with short and wide teeth and the thin, highly scalloped marginal gingiva with long slender teeth. It has been found that the subjects with long-narrow teeth have a comparatively thin periodontium, high papilla fill and exhibited more gingival recession, less probing gingival sulcus depth than the subjects who had a short-wide tooth form with a thick gingival biotype.[13]

OTHER factors which may influence the gingival biotype are growth, racial and genetics factors, body weight etc.[30,31,32]

Methods to measure gingival biotype.

Invasive and non- invasive methods have been used to evaluate the thickness of gingival biotype.

Non-invasive methods

Visual Inspection

The gingival biotype is clinically evaluated based on the general appearance of the gingiva around the tooth. If the gingiva is dense then it was considered as *thick* and *fibrotic* and if the gingiva is delicate, friable, and translucent then it is considered as *thin*. It is non-invasive, straightforward however it has a very low accuracy.[33]Eghbali et al in 2009 [34] found that simple visual inspection could not be relied as an effective method irrespective of the clinician's experience.

Probe transparency (TRAN Method)[35]

It is most commonly used method. It is carried out by placement of a probe within the gingival sulcus or the

mid-facial aspect of the tooth and evaluating for probe visibility. If the probe can be seen through the gingival tissue, it is classified as *thin.* Conversely, if the probe cannot be seen through the gingival tissue, it is classified as *thick.*

Thin biotype

Thick biotype

It is simple, reproducible, most accepted technique with a good accuracy [36], convenient to use and inexpensive with a disadvantage of difficulty in identifying in pigmented gingiva.

Ultrasonic devices[37]

It uses the pulse echo principle for the determination of biotype thickness. A sensitive, thin probe attached to an ultrasonic device measures the biotypes ultrasonically. The reading based on the criteria of if there is thin plate then it is considered as thin biotype and vice-versa (< 1.2mm thin biotype,> 1.2mm thick biotype).This technique gives accurate measurement digital display, avoids inter examiner variability, and non-invasive, but the device is costly and it is difficult to both determine the correct position for accurate measurement and successfully reproduce measurements. This device is no longer available commercially.

Cone Beam Computed Tomography[35,37]

CBCT scans have been used extensively for hard tissue imaging because of their superior diagnostic ability. Thickness of alveolar bone plate surrounding the tooth is associated with the type of biotype. Thick buccal bony plate usually corresponds to thick gingival biotype. It is simple, convenient, non-invasive, no interexaminer variation and highly accurate results can be achieved. However, there is some amount of radiation exposure, requires technical skills and increased cost for the patients. In contrast to transgingival probing and the ultrasonic device, CBCT method provides an image of the tooth, gingiva and other periodontal structures.

Invasive methods

Direct measurements [35]

The gingiva is anesthetized by topical application of an anesthetic gel. An endodontic spreader with a rubber stop/ caliper is inserted at a point at the center of the gingival margin and mucogingival junction in a perpendicular direction and this measurement is recorded against a digital caliper. It is an accurate method of measurement; however it is an invasive technique.[38]

Transgingival probing[39]

Greenberg et al. determined a periodontal biotype on the basis of gingival thickness measurements using a periodontal probe under local anaesthesia. Gingival thickness can be measured by using a periodontal probe. When the thickness is >1.5mm, it is categorized as *thick* biotype and if less than 1.5 mm, categorized as *thin*. It is simple and convenient; however, such measurements can be affected by the precision of the probe, the angulation of the probe, and the distortion of the tissue during probing.

Modified caliper

A tension-free caliper can only be used at the time of surgery and cannot be used for pre-treatment evaluation. A 2010 study by Kan et al[4] of the facial gingival biotype in maxillary anterior teeth compared visual evaluations, the use of a periodontal probe, and direct measurements with a tension-free caliper. The authors reported a statistically significant difference between visual assessment and both the periodontal probe and the tension-free caliper; however, there was no statistically significant difference when comparing the periodontal probe assessment and the tension free caliper. Based on these results, a periodontal probe in the sulcus is an adequately reliable and objective way to evaluate tissue thickness, whereas visual evaluation of the gingival biotype by itself is not as reliable as the periodontal probe or the tension-free caliper.

Observing all advantages and disadvantages of various methods direct measurement and probe transparency are good methods to detect gingival biotype clinically.

Table 2: Method of gingival biotype detection and related study[37]

Method	Study
Visual Inspection	Ochsenbein, Ross 1963 Seibert, Lindhe 1969
Probe transparency (TRAN Method)	Kan et al. 2003
Ultrasonic devices	Kydd et al. 1971
Cone Beam Computed Tomography	Fu JH et al. 2010
Transgingival probing	Greenberg 1976
Modified calliper	Kan et al. 2010

Table 3: Comparison of Tissue Response to Inflammation, Surgery and Tooth Extraction

	Thick Gingival Biotype	Thin Gingival Biotype
Inflammation	Soft tissue: Marginal inflammation; cyanosis; bleeding on probing; edema/fibrotic changes Hard tissue: bone loss with pocket formation/infrabony defects.	Soft tissue: Thin marginal redness and gingival recession Hard tissue: Rapid bone loss associated with soft tissue recession.
Surgery	Predicable soft and hard tissue contour after healing.	Difficult to predict where tissue will heal and stabilize.
Tooth extraction	Minimal ridge atrophy.	Ridge resorption in the apical and lingual direction.

Periodontal biotype: Clinical applications and its importance

The outcomes of a various dental procedures are dependent on tissue biotypes associated with it. Different responses dictate different treatment modalities. Therefore an accurate diagnosis of gingival biotype is of utmost importance in forming an appropriate treatment to achieve a predictable treatment outcome.

Supragingival tissue[40]

It has been observed that median supracrestal gingival tissue is more in thick flat biotype as compared to thin scalloped biotype. Overhanging restorations can more frequently and rapidly result in tissue destruction.

Flap handling

Procedures such as gingival curettage need to be performed more carefully consideringto the delicate nature of thin gingival tissue. In cases of flap surgery, careful handling of the flap is more significant in thin biotype cases.

Crown lengthening procedures

Periodontal surgical procedures are more predictable in thick biotypes than in thin gingiva. With crown lengthening procedures and flap procedures, it is often difficult to predict the final position of the soft and hard tissues, due to the fact that each time when a flap is reflected, there is at least 0.5–0.8 mm of bone loss.[41,42] There could be undue gingival recession following surgery. So before placement of permanent restoration in the anterior region a healing period of at least six months is desirable. In an extremely thin gingival tissue, soft tissue grafting is recommended 6–8 weeks prior to surgical crown lengthening to improve the thickness of the keratinizedtissue.[43] It has been suggested that a thick biotype may enhance the collateral blood supply to the underlying osseous structure whereas a thin biotype may compromise it.[44] Surgical trauma and periodontal flap management may influence the primary and collateral blood supply to the underlying only graft and insufficient new angiogenesis may result in ischemia.[45,46]

Regenerative procedures

Limited gingival recession has been observed following regenerative periodontal procedures in thick biotypes than in thin biotypes.[47]To achieve a predictable result with root coverage procedures a flap thickness of 0.8–1.2 mm is recommended. Thick gingival tissues ease manipulation, maintain vascularity and promote wound healing during and after surgery.[48]A thick tissue has an increased blood supply that will enhance the revascularization of bone grafts, leading to increased healing and graft incorporation. In these tissues it is able to attain and maintain primary closure. Thus the adequacy of soft tissue coverage is one of the prime factors in ensuring periodontal regeneration. Thick gingival tissues are more resistant to mucosal recession or mechanical irritation and are capable of creating a barricade to conceal restorative margins. Hence there is a need to convert a thin tissue to a thick biotype.[54]

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Ridge preservation procedure

The thin alveolar plate associated with thin periodontal biotypes, more extensive ridge remodelling is seen in thin biotype when compared to thick biotypes leading to exaggerated loss in hard and soft tissue volume. Excessive trauma or a previous history of endodontic surgery or fistula tracts may have compromised the alveolar plate. Not only is atraumatic extraction critical to minimize this post extraction remodeling, it is important to consider strategies to preserve the alveolar bone, such as socket preservation or ridge preservation procedures. Hence, in a patient with thin biotype, augmentative procedures such as socket preservation/augmentation may be performed to ensure an aesthetic and functional result in future.[49]

Prevention of post extraction alveolar bone loss is critical in assuring implant success. A number of studies have shown that there might be the loss of 1.5 to 2.0 mm in extraction ridge over the first 12 months with most loss occurring during the initial three months.[50]

A variety of approaches can be employed to address this problem, but classic method [6]involved is grafting the extraction socket and using membranes to support missing/perforated bony walls. Other approaches include the use of barrier membranes, tenting pins, collagen

plugs, connective tissue grafts, free gingival grafts, acellular dermal grafts, and advancement of the buccal flap.

Gingival biotype and Schneiderian membrane thickness or Maxillary Sinus Lining

Applicability of clinical methods to identify gingival biotype can be instituted to overcome the complication i.e. the perforation of the sinus membrane in sinus graft procedures. It has been suggested that a correlation exists between the sinus membrane thickness and the risk of perforation. Aimetti et al in 2008[51] took maxillary mucosal biopsies from the sinus floor found that the average thickness of the membrane is 0.97 ± 0.36 mm and in subjects with thick gingival biotype is 1.26 ± 0.14 mm, compared to thin gingival biotype, 0.61 ± 0.15 mm. Hence, clinical identification of gingival biotype is a reliable factor for predicting sinus membrane thickness.

Implant treatment planning

Thicker biotype is better at concealing titanium or metal margin, more accommodating to different implant position and resultant abutment angulation.[5,52] Although, cases with thin biotype variety, the selection of abutment provides more concerns due to its inability to barricade to conceal titanium or metal margin and highly prone to mucosal recession on irritation or insult. Hence for predicting the aesthetic success of an implant, the gingival biotype is a diagnostic key.

Evidence suggests that the percentage of the success rate of immediate implants in anteriors is more in individuals with thick biotypes.[53] However in patients with thin biotypes the frequency of gingival recession is high following implant restoration.[52] Thick biotypes show greater dimensional stability during remodeling compared to thin biotypes. It is assumed that in thick biotypes, the presence of lamina bone adjacent to the outer cortical plate provides the foundation for metabolic support of the cortical bone and hence its stability and sustainability. In thin biotypes, where the lamina bone is scarce or absent, the cortical bone is subjected to rapid resorption. Hence, a delayed implant must be considered when there is not enough soft and hard tissue thickness to form a stable epithelial connective tissue attachment a minimum of 3 mm of peri-implant mucosa. However immediate implants can be considered with predictable results in thick biotypes.[54,55]

Tooth extraction

Although extractions should always be atraumatic, teeth with thin gingival biotypes merit more attention due to their association with thin alveolar plates.[6,56] Atraumatic extraction and preservation of the alveolar plate are essential. Excessive force is more likely to fracture the buccal alveolar plate in thin biotype and results in bone resorption and unpredictable bone healing.

Possible strategies that should be considered while extracting teeth with thin biotypes include [6]:

- Minimizing leveraging forces toward the thin labial plate. Most of the manipulation should be focused on the interproximal area.
- Sectioning the root(s) from the tooth, when possible, to improve the likelihood for elevation.
- Using periotomes to expand and elevate the tooth with controlled force focused on the periodontal ligament space.
- Using a ratchet extraction device to apply reciprocating force on adjacent teeth while extruding the amputated root tip out the socket (most effective and atraumatic approach for the broken tooth)

Orthodontic therapy

The gingival tissue with a little horizontal diameter in the presence of a dental plaque is more susceptible to apical migration of connective tissue attachment with marginal gingiva especially near teeth under the influence of orthodontic force**.** It may sometimes lead to soft tissue recession or hard tissue dehiscence and fenestration.[57] Hence, such cases should be approached with more caution. Another consideration could be placement of mini-screws where a thin biotype warrants more caution.

However, in contrast to this article cases with thin gingiva caused by the prominent position of the teeth, there is no need for pre-orthodontic gingival augmentation procedures. The recession and bone dehiscence will decrease when the tooth is moved in amore proper position within the alveolar bone.[58]

Prosthesis aesthetics

As the thin biotype is more prone to recession of gingiva, it has been observed that in relation to metal ceramic prosthesis over a period of 5 years, significantly more gingival recession is observed after prosthesis placement in thin biotype as compared to thick biotype.[59]This emphasize the importance of assessment and management of thin biotype cases at the time of prosthesis placement. In areas of high esthetical requirement, biotype enhancement can prevent such unpleasant clinical scenario. Therefore, more caution should be exercised while planning a subgingival margin placement for patients with a thin biotype as minimal tissue injury may result in adverse outcome in future.

Treatment

The gingival thickness determines the final aesthetic treatment outcome. Therefore it is essential for the clinician to identify the tissue biotype and to convert the thin biotype to a thick biotype. A pseudo thick gingiva is when an originally thin gingiva is converted to a thick gingiva.[60]A study demonstrated that bone loss can be controlled in thin biotype patients, if the biotype is augmented prior to the placement of implant.[61]

The best periodontal surgical technique to convert a thin soft tissue to a thick biotype is through Subepithelial connective tissuegrafting.[62]A connective tissue graft harvested from palate/tuberosity is placed at the site of thin biotype subepithelially. For the same, either a full or

partial dissection can be done. Once the graft is in position, it is sutured. Once healing is completed, a thin biotype is converted into a stable thick biotype. This can be attributed to the primarily fibrous content of the graft and the bulk that they provide at the recipient site. It is the most reliable and frequently documented method. However, donor site morbidity, limited availability, and increased operating time are the disadvantages of it.

Acellular dermal matrix[63]also can be used where placement and healing mechanism is similar to that of the tissue graft with an advantage of lowering the patient morbidity due to the absence of a second donor site; however, the high cost and limited availability are its drawbacks.

Other soft tissue augmentation procedure include: Modified roll technique also can be used.[64] Oral physiotherapy can improve tissue keratinization.

Conclusion

In the era of evidence based interdisciplinary dentistry, the treatment plan, treatment response, and prognosis of dental procedures vary greatly between teeth with different biotypes. Hence, the basic knowledge and assessment of gingival or periodontal biotype has become an important routine in clinical decision making. So by taking into consideration the gingival tissue biotypes during treatment planning, more appropriate strategies for periodontal management may be developed, resulting in more predictable treatment outcomes.

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