Review Article

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GINGIVAL BIOTYPE: A KEY DETERMINANT IN PERIODONTAL TREATMENT

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ABSTRACT:
Gingival biotype has a significant impact on the outcome of restorative and regenerative therapy. The morphologic characteristics of the gingiva depends on several factors, like the dimension of the alveolar process, the form of the teeth, events that occur during tooth eruption, and the position of the fully erupted teeth. Different tissue biotypes have different gingival and osseous architectures and they exhibit different pathological responses when subjected to inflammatory, traumatic or surgical insults, which in turn dictate different treatment modalities. Various invasive and non invasive methods have been employed for measurement of the gingival tissue form. Until now, none of the described parameters can be considered as gold standard in assessing periodontal biotype. This review article highlights the characteristics of gingival biotype, response to treatment and its clinical significance, methods to assess gingival thickness used till date.
Key words: Gingival biotype, Ultrasonography, implants, probe transparency

INTRODUCTION:

The gingival perspective of esthetics is concerned with soft tissue covering around the teeth . The gingival morphology plays an important role in determining the final esthetic outcome, therefore during treatment planning, it is important to recognize various forms of gingival tissue. Different gingival biotypes respond differently to inflammation, trauma and parafunctional habits.[1] Identification of gingival biotype helps in better determination of the treatment outcome in various branches of dentistry and is also important in clinical practice since differences in gingival and osseous architecture have been shown to exhibit a significant impact on the outcome of restorative therapy.[2]

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The morphological characteristics of gingiva depends on gingival complex, tooth morphology, contact points, hard and soft tissue considerations and gingival biotype.[3] Ochsenbein & Ross were the first one who indicated that the two main types of gingival biotype, thick and thin. Later, Seibert and Lindhe coined the term periodontal biotype to describe different gingival architecture types based on buccolingual thickness.[4] The thick biotype consists of flat soft tissue and thick bony architecture and is found to be most prevalent in the population.[3] This type of tissue form is dense and fibrotic with large zone of attachment, thus making them more resistant to gingival recession. Whereas, thin gingival biotype is delicate, highly scalloped soft tissue with thin bony architecture characterized by bony dehiscence and fenestrations, which is more prone to recession, bleeding, and inflammation. Claffey and Shanley [5] defined the thickness not more than 1.5 mm as a thin biotype while more than 2 mm as a thick biotype.[6]

Various methodologies, invasive and non invasive, have been proposed for measurement of the gingival tissue form. This includes visual inspection, ultrasonic devices, transgingival probing, and Cone beam computerized tomography imaging.

Tissue biotype is a critical factor that determines the result of dental treatment. The initial gingival thickness is significant as it may predict the outcome of root coverage procedures and restorative treatments. However, periodontal surgical techniques can enhance tissue quality resulting in a more favorable treatment outcome.

VARIOUS CHARACTERISTICS OF GINGIVAL BIOTYPES

Various forms of gingival biotypes as suggested by various authors are described are as follows:

The pioneers were Ochsenbein & Ross , who proposed 2 main types of gingival anatomy— flat and highly scalloped and suggested that flat gingiva was related to a square tooth form and scalloped gingiva was related to a tapered tooth form.[7]

Lindhe categorized the gingiva into ‘‘thick - flat’’ and ‘‘thin – scalloped’’ biotypes. A gingival thickness of > 2 mm was considered as thick tissue biotype and a gingival thickness of <1.5 mm was considered as thin tissue biotype.[5]

Becker et.al, measured from the height of the bone interproximally to the height at the direct midfacial, and proposed three different periodontal biotypes: flat, scalloped and pronounced scalloped gingiva.[8]

Kois , suggested a classification system related to periodontal biotype based on the relationship between the cementoenamel junction (CEJ) and the crest of the bone. The three categories included: (1) normal crest: alveolar crest is 3 mm apical to the CEJ (85% of the population), (2) high crest: alveolar crest is < 3 mm apical to the CEJ (2% of the population) (3) low crest: alveolar crest is > 3 mm apical to the CEJ (13% of the population). [9]

De Rouck et al, made an assessment of the width to length ratio in the central incisor teeth in the mandible, the inter incisor height of a gingival papilla , the width of the keratinized gingiva , and thickness of a gingiva measured by Kan, using a periodontometer while probing the transparency. Based on the above measurements, the author classified gingival biotype as:

1) Thin gingival biotype, slender tooth form, narrow zone of keratinized tissue, and a high gingival scallop ,which occurred in one third of the study population and was most prominent among females.

2) Thick gingival biotype, quadratic tooth form, broad zone of keratinized tissue, and a flat gingival margin, which occurred in two thirds of the study population and mainly among males. [10]

METHODS TO DETERMINE GINGIVAL THICKNESS

Different parameters have been used to assess the gingival biotype. However, none of the described parameters can be considered as best or most reliable. These methods include conventional histology on cadaver jaws, injection needles, transgingival probing, histologic sections, cephalometric radiographs, probe transparency ultrasonic devices, and Cone-Beam Computed Tomography (CBCT).[11]

Until now, there is no precise definition of how thick biotype can be compared to a thin one. One of the reasons may be seen in the fact that thickness of the gingiva has been assessed at different vertical levels. Earlier, the invasive methods were used to determine the gingival thickness; direct measurement [12] was used but had various limitations i.e. invasive approach, lack of reproducibility, accuracy, improper angulation and pressure. To overcome these limitations, non invasive methods were devised; the ultrasonic devices [13] and cone beam computed tomography [14] but these methods are technique sensitive and quite expensive. Manual assessment using a caliper after tooth extraction [15], a syringe with endodontic depth marker or cone beam radiographs without reference objects have limitations of their accuracy. The most recent technique devised is a modified radiographic technique [16] described by Alpiste-Illueca [17] ,which determined that different morphometric parameters such as crown width/crown length ratio and gingival width could represent surrogate parameters to anticipate the gingival thickness at the cementoenamel junction.

Direct measurements: Greenberg et al. [12] determined a periodontal biotype on the basis of gingival thickness measurements using a periodontal probe under local anesthesia. Periodontal probe , injection needle or an endodontic tool with a silicone limiter have been frequently used to determine thickness of the gingiva When the thickness is >1.5 mm, it was categorized as thick biotype and if less than 1.5 mm, it is considered as thin. This method has inherent limitations, such as precision of the probe, the angulation of the probe and distortion of tissue during probing. [1]

Periodontal Ultrasonography: The use of ultrasonic devices to determine thickness is a non invasive method. One of the first reports of ultrasonography in periodontology was given by Spranger [18] who tried to determine the height of the alveolar crest in periodontitis patients. In a study done by Tsiolis et al, they found that the ultrasonic scanner showed better repeatability than both the transgingival and the direct methods. [19] An ultrasound gingival thickness measurement (UGTM) is a safe and painless method, but an appropriate instrument is required. B-scan ultrasonic probe with 10 MHz frequency, with head diameter of 5 mm is required. [13] Muller et al. [20] used Sonic Devices with A-scan head of 5 MHz frequency, an initial delay of 0.3 ± 0.2 ms and ultrasonic impulse velocity of 1514 m/s for the measurement. The inaccuracy of such ultrasonic examination was about 25%. [2] Bednarz et al, used Pirop Ultrasonic Biometer (figure 1,2)[2] with the A-scan probe with 20 MHz frequency, in his study to measure thickness of soft tissues, that cover bones and teeth in the oral cavity, in the range 0.25 to 6 mm, with accuracy up to 0.01 mm.

A new M-mode “oscyloscopic” presentation is also being investigated. It allows to show parameters of thickness in one or many places during moving the probe from gingival margin to behind the mucogingival junction. Salmon et al. in 2010 presented an ultrasound brightness-mode (B-mode) prototype device with 25-MHz high frequency. This device showed that tooth, implants surface, alveolar bone and surrounding soft tissue of periodontium are clearly visible. In this way the periodontal biological width, gingival thickness, bone dehiscence can be identified and measured.[21] Ultrasonics has been applied in the description of various gingival phenotypes, identification of suitable areas for harvesting connective tissue grafts, clinical monitoring of biodegradation dynamics of implanted membranes for guided tissue regeneration, as well as surgical root coverage. [22] The repeatability variation ,as measured by ultrasonic devices, were best at certain tooth types with rather thin gingiva.[23] The difficulty to determine the correct position for attaining reproducible measurements, and the unavailability and a high cost of the device limit the use of this method.

Cone-Beam Computed Tomography:

CBCT is used to visualize and measure thickness of both hard and soft tissues. Various authors reported that CBCT measurements of both bone and labial soft tissue thickness are accurate and concluded that CBCT measurements might be a more objective method to determine the thickness of both soft and hard tissues than direct measurements. In contrast to transgingival probing and the ultrasonic device, CBCT method provides an image of the tooth, gingiva, and other periodontal structures. Moreover, measurements can be repeatedly taken at different times with the same image obtained by ST-CBCT (soft tissue CBCT) which is not feasible by other methods.[24]

Visual inspection: It is the simplest method available. The gingival biotype was clinically evaluated based on the general appearance of the gingiva around the concerned tooth.

The gingival biotype is considered thick (figure 3)[15] if the gingiva is dense and fibrotic in appearance and thin (figure 4)[15] if the gingiva is delicate, friable, and almost translucent.[15] Simple visual inspection may not be considered a valuable method to identify the gingival biotype as nearly half of the high-risk patients are overlooked.[25]

Probe transparency:

Kan et al.[15] presented a simple method of periodontal type determination, which utilizes translucency of the free gingiva during the probing of gingival grooves in teeth. Visual inspection of the transparency of the periodontal probe through the sulcus has become the most frequently used method for discrimination of thin and thick biotypes. The gingival biotype is considered thin if the outline of the probe is shown through the gingival margin from the sulcus.[1] The gingival tissue's ability to cover any underlying material's color is necessary for achieving esthetic results, especially in cases of implant and restorative dentistry, for this purpose subgingival alloys are widely used. Using a metal periodontal probe in the sulcus to evaluate gingival tissue thickness is the simplest way to determine thin gingival biotype , the tip of the probe is visible through the gingiva (figure 5,6).[26] This method is minimally invasive, and periodontal probing procedures are performed routinely during periodontal and implant treatments.

Modified Caliper: A tension-free caliper (figure 7)[15] can only be used at the time of surgery and cannot be used for pretreatment evaluation.[26] Kan et al conducted a study , in which a caliper was modified by cutting the spring and therefore eliminating the tension of the caliper arms to avoid excessive pressure on the gingival tissue. The examiners were calibrated so that the gingival tissue thickness was directly measured without any undue pressure to the gingiva at approximately 2 mm apical to the free gingival margin on the midfacial aspect of extraction sockets. In this study, they compared visual evaluations, the use of a periodontal probe, and direct measurements with a tension-free caliper. Based on the results of the study, a periodontal probe in the sulcus and the tension-free caliper were more reliable and objective way to evaluate tissue thickness, than visual evaluation.[15]

Radiographic morphometric study: In the study conducted by Stein et al [16], they used the radiographic technique described by Alpiste Illueca [17], to evaluate the correlation of different morphometric parameters with the thickness of the buccal gingiva and alveolar bone at different apico-coronal levels. The result showed that the gingival thickness at CEJ, middle third and and directly above the bone crest level were strongly correlated with the alveolar bone crest than between the thickness of other parts of the gingiva and more apical parts of the alveolar bone plate. They demonstrated a positive correlation of the crown form and the width of the keratinized gingiva with all thickness parameters. The limitations of the study were : i) measurements at the base of the free gingiva comprise the sulcus width, which might be considered as bias. ii) despite the exact parallel positioning, a strictly tangential projection over the entire length of the plate is difficult.[16] Nevertheless, this is the most recent and most accurate technique used till date.

CLINICAL SIGNIFICANCE:

During treatment planning, the soft tissue biotype should be taken into consideration as it affects the final treatment outcome. Soft tissue thickness and contours are important diagnostic factors that influence the esthetic outcome in periodontal treatment. Thick gingival tissue is generally associated with periodontal health. It was suggested that since these two tissue biotypes have different gingival and osseous architectures, they exhibit different pathological responses when subjected to inflammatory, traumatic, or surgical insults. These differences are listed in the table given below.(Table 1).

Gingival biotype and tooth form: Clinical appearance of normal gingival tissue reflects the underlying structure of the epithelium and lamina propria. The clinical appearance of healthy marginal periodontium differs from subject to subject and even among different tooth types. Many features are directly genetically determined, others seem to be influenced by tooth size, shape and position and biological phenomena such as growth or ageing.[27] Probe visibility through the gingival sulcus was a good clinical indicator for a thin periodontal biotype, while a lack of probe visibility through the sulcus was an indicator for a thick/average periodontal biotype. Central incisors had the most variability in probe visibility overall. Although a patient with a thin biotype is more likely to present with a scalloped gingival architecture, patients with both thin and thick periodontal biotypes may appear as a flat or scalloped gingival architecture depending on their tooth form (tapered, square, oval, square tapering) and tooth position. [28] Oschbein and Ross were the first to document the relation of flat thick gingival form with square tooth form and thin gingival biotype with tapered tooth form. [4]

Gingival biotype and root coverage: More gingival recession has been observed following regenerative procedures in thin tissue biotype, while thick gingiva has been seen to be more resistant to recession following surgery. This may arise due to variability in tissue response to surgical trauma.[29] Morris, Lindhe documented that individuals with tapered crowns have a thinner biotype, making them more susceptible to gingival recession. [4] In root coverage procedures, a thicker flap was associated with a more predictable prognosis. An initial gingival thickness was found to be the most significant factor that influences the prognosis of a complete root coverage procedure. A flap thickness of 0.8–1.2 mm was associated with a more predictable prognosis.[30] The gingival thickness determines the final esthetic treatment outcome. Soft tissue grafting in areas of thin biotypes can enhance the quality of the gingival tissue. The best way to convert a thin soft tissue to a thick biotype is through subepithelial connective tissue grafting. Oral physiotherapy can improve tissue keratinization.[31] Thick gingival tissues are easy to manipulate, maintain vascularity and promote wound healing during and after surgery. A thick tissue has an increased blood supply that will enhance the revascularization of bone grafts, leading to increased healing and graft incorporation.

Gingival biotype and underlying osseous anatomy: In 1923, Hirschfeld observed a thin alveolar contour and assumed that such a thin bony contour was probably accompanied by a thin gingival form.[32] According to the researches, it has been shown that a thin biotype is associated with a thin underlying labial plate and a thick or average biotype is associated with a thicker labial plate. A thin biotype is associated with a significantly greater distance between the CEJ and the bony crest than a thick biotype. 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. The study done by Cook et al. 2011, provides the first human evidence to support the commonly held opinion that patients with a clinically thick/average biotype have a thicker labial plate and a smaller distance from the CEJ to the alveolar crest than subjects with a thin clinical biotype. [28]

Gingival biotype and crown lengthening: 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. 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 a study conducted by Pontoriero R [33] and Arora et al [34] , the role of biotype on the amount of tissue rebound after crown lengthening has been studied, they found that mean tissue regrowth in patients with thick biotype was significantly greater than those with thin biotype.[35,36] 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.[1]

Gingival biotype and ridge preservation:

A thin gingival biotype is associated with a thin alveolar plate; more ridge remodeling has been found in this biotype when compared with thick periodontal biotype. Tooth extraction in thick biotypes result in minimal ridge atrophy, whereas, in thin bony plates traumatic extractions may result in fracture of the labial plates and undue alveolar resorption.[1] If the site is to be used for implant placement, atraumatic extraction and ridge augmentation protocols should be considered.

Preservation of alveolar dimensions (such as socket preservation or ridge preservation techniques after tooth extraction) is important for achieving optimal esthetic results in thin biotypes. [37,38]

Gingival Biotype and Implants: Gingival biotype is referred to as soft tissue biotype since the advent of implants, this has been renamed to encompass tissue around both teeth and implants.[1] The thick biotype is more resistant to recession, is better at concealing titanium, and is more accommodating to different implant positions.[39,40] The long term stability of gingival margins around implants and adjacent teeth will depend upon the sufficient height and thickness of the facial bone. The thicknesses of the crestal bone on the buccal aspect significantly influence remodeling during the initial four month healing period after immediate implant placement. Sites with >1 mm thickness showed minimal vertical resorption of buccal crest when compared to sites with thinner bones. To form a stable epithelial connective tissue attachment a minimum of 3 mm of periimplant mucosa is required which serves as a protective mechanism for the underlying bone. Hence, a delayed implant must be considered when there is not enough soft and hard tissue thickness. However, immediate implants can be considered with predictable results in thick biotypes.[1,41] The thick biotype tend to maintain the implant papillae height.[5] The thicker biotype prevents mucosal recession, hides the restorative margins and camouflages the titanium implant shadows. It also prevents biological seal around implants, thus reducing the crestal bone resorption.[4]

CONCLUSION:

Different tissue biotypes have different gingival and osseous architectures and they exhibit different pathological responses when subjected to inflammatory, traumatic or surgical insults. These different responses, in turn dictate different treatment modalities. The morphologic characteristics of the gingiva depends on several factors, like the dimension of the alveolar process, the form of the teeth, events that occur during tooth eruption, and the position of the fully erupted teeth. By understanding the nature of tissue biotypes, clinicians can employ appropriate periodontal management to minimize alveolar resorption and provide more favorable results after dental treatment. More gingival recession has been observed following regenerative procedures in thin tissue biotype, while thick gingiva has been seen to be more resistant to recession following surgery. This may arise due to variability in tissue response to surgical trauma. Classification of periodontal biotype may assist practitioners in various clinical situations, including esthetic crown lengthening, implant placement in the esthetic zone, extraction site wound healing, and mucogingival therapy. A clinician's knowledge in identifying gingival biotypes is paramount in achieving optimal treatment outcomes. Various invasive and non invasive methods have been used to measure tissue thickness. Till date, no method can be considered gold standard for the measurement. Thus, more appropriate strategies for periodontal management needs to be developed, resulting in more predictable treatment outcomes.

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FIGURES:

Figure 1: Pirop Ultrasonic Biometer

Figure 2 : The head of Pirop ultrasonic biometer during examination of palatal masticatory mucosa thickness

Figure 3 : Thick gingiva as on visual inspection

Figure 4: Thin gingiva as on visual inspection

Figure 5: Probe visible through the sulcus

Figure 6: Probe not visible through the sulcus

Figure 7: Measuring thickness using Modified Caliper

TABLES:

	Thick gingival biotype	Thin gingival biotype
Inflammation	Soft tissues: marginal inflammation with pocket formation, bleeding on probing, oedema Hard tissues: formation of infrabony defect	Soft tissues: marginal recession without pocket formation Hard tissues:loss of thin vestibular bone plate
Surgery	Predictable hard and soft tissue healing	Delicate and unpredictable tissue healing(recession)
Tooth extraction	Minimal ridge resorption	Extensive ridge resorption in apical and lingual direction

Table 1