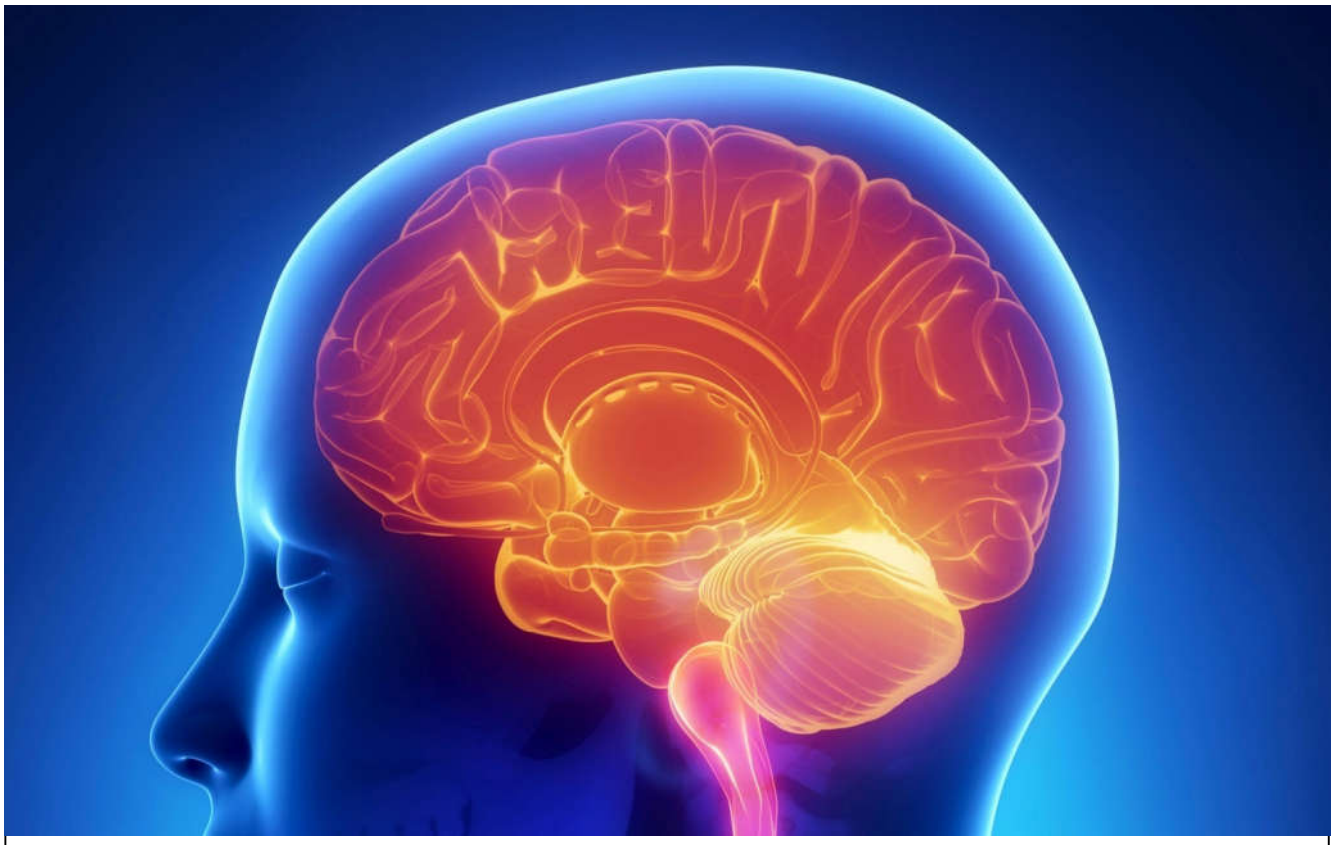

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ROLE OF TISSUE MORPHOLOGY (BIOTYPE AND BIOFORM) IN PERIODONTAL SURGICAL PLANNING

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ABSTRACT

Advances in periodontics is giving way to new methods and approaches to decide upon the best surgical plan possible for a specific area in a particular patient. So for this, measurement of different gingival dimensions plays a pivotal role which is indirectly associated with the tooth type and shape. This article highlights the significance of these small yet crucial but often overlooked considerations before any periodontal surgical planning.

INTRODUCTION

Gingival dimensions, like width and thickness show great intra- and inter-individual variation, which are associated with tooth type and shape, and are certainly also genetically determined.[1] Recently, distinct gingival phenotypes have been identified on a subject level, and their existence later confirmed in an independent, periodontally healthy population of young adults by using cluster analysis.[2] Individuals with a thin phenotype had slightly more recession than subjects with wide and thick gingival tissues. Most interestingly, masticatory mucosa was rather thin in any other region of the oral cavity, in particular that of the hard palate, [2] rendering harvesting connective tissue for surgical root coverage more difficult in these individuals.

Tissue biotypes are associated with the host response against periodontal diseases, the outcomes of periodontal therapy, root coverage procedures, and the remodeling process after tooth extraction.[3] Gingival thickness affects the treatment outcome possibly because of a difference in the amount of blood supply to the underlying bone and susceptibility to resorption.[3, 4]

Gingival or periodontal diseases are more likely to occur in patients with a thin gingival phenotype, and the remodeling process after tooth extraction reportedly results in more dramatic alveolar bone resorption in the apical and lingual directions for ridges associated with thin biotypes.[3] Fu *et al.*[4] also showed a positive correlation between thickness of the gingival phenotype and its underlying bone.

It is important to realize that the dimension of the gingiva which regenerates following the "gingivectomy" or "flap" procedure differs following healing in some important aspects.[5] Thus, while the gingiva which regenerates following "gingivectomy", consistently has a narrow zone of keratinized epithelium and a small buccolingual width, the gingiva which forms following "flap" surgery consistently has a wide zone of keratinized epithelium, a comparatively long junctional epithelium and is comparatively wide in bucco-lingual directions. The findings suggest that in gingival sites with a narrow, in contrast to sites with a wide zone of keratinized gingiva, subgingival plaque formation in the presence of a sub gingival restoration may result in recession of the gingival margin.[6]

More gingival recession was found following regenerative surgery in patients with a thin gingiva.[7]These observations illustrate that disparities in aesthetic treatment outcome could arise as a result of variability in tissue response to surgical trauma. Subjects, especially with a thin-scalloped biotype seem at risk for aesthetic failure and therefore, need to be accurately identified.

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Tooth shape has been found to have an impact on periodontal surgery, such as crown-lengthening, full-coverage restorations at or apical to the gingival margin, and the placement of dental implants.[8] Understanding tooth shape prior to periodontal surgery is an important factor for treatment planning to achieve acceptable esthetic outcome. Commonly, in true triangular teeth, the gingival papilla will not completely fill the embrasure space. In this sense, the presence of a triangular central incisor that requires replacement with a single restoration where the adjacent central incisor is not to be replaced, could result in a less than ideal esthetic result because of the presence of black triangles or non-symmetric crown shapes. Anticipating treatment limitations by understanding the morphologic characteristics of the underlying bone is an important phase of the treatment planning discussion with a patient.

The presence of interdental papillaeand healthy gingiva, which have a harmonious relation with the natural dentition, is an important esthetic aspect that needs to be considered during diagnosis and treatment planning. With the ever increasing awareness amongst our patients, we have a dual responsibility of not only restoring the loss of function but also meeting the esthetic expectations of our patients post therapy.

The loss of gingival papilla height can result in open gingival embrasures, phonetic problems, food impaction and esthetic concerns. The cause of open gingival embrasures is multifactorial. Potential causes include:-

- Dimensional changes of papilla during orthodontic alignment,
- Loss of periodontal attachment resulting in recession,
- Loss of height of the alveolar bone relative to interproximal contact,
- Length of embrasure area,
- Root angulations,
- Interproximal contact position,
- Triangular-shaped crowns

Ko-Kimura *et al*.[9] have shown that 67% of the population over 20 years of age was found to have open embrasures compared with 18% under 20 years of age. This difference was attributed by the authors to the thinning of oral epithelium, decrease in keratinization, and reduction in papilla height as a result of aging.

Gingival biotype can affect the results of periodontal therapy, root coverage procedures, and implant placement.[10, 11, 12] It has also been shown that subjects with thin and vulnerable marginal tissue may be prone to the development of gingival recession following non-surgical periodontal therapy.[12] Furthermore, palatal mucosa usually serves for harvesting full epithelialized grafts or relatively thick connective tissue grafts and according to a study done by Muller HP *et al* 2000,[2] it was proposed that specific characteristics at maxillary front teeth are also easily found in other parts of dentition, in particular, palatal mucosa was found to be rather thin in subjects with a thin and narrow gingiva and a slender shape of upper teeth, therefore, serving as an anatomical barrier for harvesting palatal graft.

Inflammatory Periodontal Disease

In the development of periodontal disease, the inflammation generated by plaque on the root surface extends into the tissue for a distance of 2mm in all directions. In patients with a thin biotype, the distance from the root surface to the oral epithelial surface (that is the thickness of the whole periodontium encompassing cementum, periodontal ligament, bone and gingivae) can be less than 2mm. Inflammation will, therefore, involve all the structures, rapidly resulting in recession. On the other hand, in thick biotype patients with a thick alveolar housing around the teeth, the 2mm radius of inflammation will damage cementum, ligament and bundle bone only, producing a periodontal pocket. There will be variations in the thicknesses of the different layers around each tooth, but this is to help us understand how the same periodontal disease processes result in different effects. Thin tissue is more likely to recede following non-surgical periodontal treatment.[13]

Crown Lengthening Surgery

Patients with a thick tissue biotype are likely to get more rebound of the gingival margin after crown-lengthening surgery is performed.[14] When treating these cases, it is essential that the correct amount of bone removal is performed so that the biological width is correctly set up. While this has not been explicitly reported, it is not unreasonable to expect that patients with a thin biotype may be more prone to additional recession following crown-lengthening surgery.

In clinical practice, the identification of the gingival biotype is considered important because differences in gingival and osseous architecture have been shown to exhibit a significant impact on the outcome of restorative therapy. That is Pontoriero & Carnevale (2001)[15] observed that natural teeth showed more soft tissue regain following crown lengthening procedures in patients with a thick gingiva than in those with a thin gingiva. This observation is in line with a higher prevalence of gingival recession in the latter as reported by Olsson & Lindhe (1991).[16]

Tissue Biotype and Root Coverage Surgery

According to McFall, tissue thickness in the recipient site and the donor site are key factors in how mucogingival defects are treated.[17]An initial gingival thickness was found to be the most predictable factor for predicting the success of complete root coverage procedures.[7] There is a correlation between flap thickness and complete root coverage.[11]

In patients with a thick soft tissue biotype, healing following root-coverage surgery is predictable; whereas the opposite is true for those with thin tissue. Unfortunately, recession is usually found in those with the thin biotype, where it has been a contributory factor in the development of the recession. Because of this, interpositional connective tissue grafts are used between the pedicle and the root surface to increase the thickness of the tissue. Various reports have suggested that for optimal root coverage, the tissue needs to be augmented to a minimum thickness.

Palatal masticatory mucosa is widely used as a donor tissue in periodontal plastic surgery for root coverage procedures, for increasing the width of attached gingiva, and for alveolar ridge augmentation.[18, 19] The volume of tissues that can be obtained from this donor site is important for the selection of treatment modalities and can affect the surgical outcome, particularly in ridge augmentation procedures to correct moderate and severe ridge resorption.[20] The main donor sites for connective tissue

graft for soft tissue augmentation are the palate, maxillary tuberosity area, and edentulous sites. The success of this technique depends on the thickness of the graft tissue obtained.[21] The graft obtained can shrink, if it is too thin, and there can be problems with revascularization and healing, if it is too thick (Morman *et al*.).[22]

Mucosal thickness has been found to be thinner in younger subjects as compared to older subjects. It is possible that the thickness of the ortho-keratinized epithelial layer of the hard palate mucosa increases with age, resulting in the thicker palatal mucosa in the older subjects. In addition, the hard palate possesses a submucosal layer, which contains various amounts of adipose tissue and small mucous glands. There are other factors that influence the mucosal thickness such as racial, genetic factors, and body weight. The subepithelial connective tissue graft results in a better aesthetic outcome, but requires thicker donor palatal tissue than the free gingival graft procedure.[23] Mucosal thickness was observed to be more in male as compare to female. This was in accordance to the study done by Studer *et al*., though it was not statistically significant.[24]

Tissue Biotype Consideration in Implant Planning

This really follows on from above. Once the implant is placed and the alveolar form is hopefully re-established, this situation needs to be maintained. Peri-implant tissue health seems to depend, in some part at least, to there being immobile keratinized tissue around the emergent restoration.[11] As around the teeth, thin peri-implant soft tissue seems to be more prone to recession and less likely to develop nicely formed papillae around the implant restorations.[11]

Studies have examined how mucosal thickness and biologic width affect crestal bone loss around implants. A 1996 animal study by Berglundh&Lindhe concluded that thin gingival tissue can lead to marginal bone loss during formation of the peri-implant biologic width.[25] Another histologic study by Huang *et al* reported that implant sites with thin mucosa were prone to angular bone defects, while stable crestal bone was maintained in implants surrounded by thick mucosa. According to Abrahamsson *et al*, thick tissues (that is, ≥2.5 mm) can avoid significant crestal bone recession; however, the authors recommend avoiding supracrestal placement of implants if an implant is surrounded by a thin biotype.[26]

Gingival recession is one of the most common complications resulting from single anterior tooth implant placement. Gingival biotype is a diagnostic key for predicting the esthetic success of an implant.[14] According to Evans & Chen, gingival recession increases in patients with thin biotypes immediately after single implant restorations.[27] Furthermore, papilla between immediate single implants and adjacent teeth is significantly associated with a thick gingival biotype. Patients with thick-flat mucosa tended to maintain the implant papillae height.[28] Dramatic alveolar resorption in the apical and lingual direction is possible in patients with a thin biotype.[29] The loss of peri-implant tissues may result in facial plate loss, with the implant taking on a grayish color; additional bone and soft tissue grafting surgeries may be necessary in such cases. Immediate placement of an implant in a thick gingival biotype offers predictable results.[29]

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.[30]

Treatment planning must address hard and soft tissue deficiencies and combine this with precision in implant placement. Recreating what nature provided can be a formidable challenge. The predictability of the aesthetic outcome of an implant restoration is dependent on many variables including but not limited to the following: [31]

1. Patient selection and smile line
2. Tooth position
3. Root position of the adjacent teeth
4. Biotype of the periodontium and tooth shape
5. The bony anatomy of the implant site
6. The position of the implant

Characteristics of the soft tissue biotype will play a prominent role in final planning for the shoulder position of the implant. A thin biotype with highly scalloped tissue will require the implant body and shoulder to be placed more palatal to mask any titanium show-through. When implants are placed toward the palate a slightly deeper placement is required to allow for proper emergence profile. The periodontal biotype of adjacent teeth may have an effect on the phenotypic features of the transplanted site.[31]

It has been suggested that a thin biotype may compromise the collateral blood supply to the underlying osseous structures, whereas a thick biotype may enhance it.[32] Flap management and surgical trauma may also influence the degree of primary and collateral blood supply to the underlying onlay graft, and ischemia may result from a lack of adequate new angiogenesis.[33-35] In one retrospective review of esthetic outcome 18.9 months after immediate implant placement, sites with a thin tissue biotype had a higher frequency of recession ≥ 1mm compared to thick sites.

The aforementioned factors could have an impact on the healing of onlay grafts. It seems reasonable to expect more bone volume loss in patients who present a highly scalloped architecture, bone dehiscence, and fenestrations compared to those with a thick, flat architecture. Thus, the biotype of adjacent teeth could dictate the degree of volume loss at the transplanted site.

Decisions regarding the surgical plan and implant selection depend on the mucosal dimensions. Furthermore, flapless implant surgery is being increasingly practiced in recent years where the positioning of the implant is out of the direct view of the surgeon. Horizontal and vertical implant positions on alveolar ridge influence the degree of bone resorption and esthetics.[36] Thus, the evaluation of mucosal dimensions in the implant site (missing tooth region) is important to achieve satisfactory implant results.

Gingival Biotype and Schneiderian Membrane Thickness

The most common complication during sinus graft procedures is perforation of the sinus membrane. This condition may occur after the sinus floor is accessed through the lateral wall or the ridge crest.[37] Clinical observations have prompted clinicians to suggest a correlation between the sinus membrane thickness

and the risk of perforation. A 2008 study by Aimetti *et al*.[38] showed that gingival thickness is a reliable factor for predicting sinus membrane thickness. They reported that healthy sinus membranes are thicker in subjects with a thick gingival biotype than in those with a thin gingival biotype. Although it has been suggested that the thickness of the marginal periodontium is genetically determined, no knowledge is yet available concerning the sinus mucosa.

Pommer *et al*.[39] investigated the mechanical properties of the sinus membrane in vitro and showed that thicker membranes have significantly higher load limits. A reason for these results is that the force necessary for membrane elevation from the bony sinus floor may not be endured by a thin sinus membrane. It may be suggested that thin gingival phenotype is a risk factor for membrane perforation because of the correlation of gingival phenotype with sinus membrane thickness and residual ridge height. This is important clinically to predict risk factors for sinus membrane perforations during sinus-lift procedures, particularly if computed tomography (CT) or cone beam computed tomography (CBCT) evaluations are not possible.

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. Ridge preservation should be considered for most thin biotype cases. Preservation of alveolar dimensions (such as socket preservation or ridge preservation techniques after tooth extraction) is critical for achieving optimal esthetic results in thin biotypes; atraumatic extraction also may be necessary.[40]

Gingival Biotype and Bleeding On Probing

It was observed that bleeding on probing is only weakly associated with the presence of supragingival plaque. Among other, still ill-defined, intrinsic and extrinsic factors which modify the bleeding status of gingiva, smoking, intake of non-steroidal anti-inflammatory drugs, or genetic polymorphisms have called considerable attention in recent years. Interestingly, a higher full-mouth bleeding score was associated with thinner gingiva. This relationship was demonstrated by considering variables operating at both the subject and tooth level simultaneously. Thus, thin and vulnerable gingiva tended to bleed more frequently than thicker periodontal tissues. In contrast, local bleeding on probing was not significantly affected by facial gingival thickness, which is in accordance with observations made in most of the previous studies.[41]The most probable reason is quite low bleeding frequency at these locations in the studies.[42]

Average plaque index was positively associated with gingival thickness. A higher mean plaque score certainly leads to generalized gingival inflammation, and swelling of marginal tissues might be measurable with the ultrasonic device.[43]

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