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Review Article

Mucosal Phenotype as A Multidisciplinary Approach: A Narrative Review

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ABSTRACT

Objectives: *The Gingival phenotype (GPh) or soft-tissue periodontal phenotype is critical for decision making during treatment planning and aesthetic outcomes in several fields of dentistry. The aim is to bring and summarize the crucial literature about GPh.* ***Data:*** *Data was collected according to: title of article, study design, and keywords.* ***Method:*** *Searching the Medline database (PubMed) and complementing by manual searches to better reaching the important primary and secondary type of studies. The result of search is reported by PRISMA flow-diagram.* ***Conclusion:*** *As one of the major risk factors of peri-implant inflammation is GPh; Careful diagnosis of GPh at the time of tooth replacement may prevent from developing mucogingival defects, or recession following periodontal and orthodontic treatment. Gingival phenotype has inter-individual and intra-individual variation; Thicker GPh is in molars rather than premolars and incisors, and in maxillary teeth rather than in mandibular and modifying GPh is becoming a trend through the use of Hyaluronic Acid (HA) or Injectable-Platelet Rich Fibrin (i-PRF) with microneedling as a minimally invasive therapy. Skeletal class (I and III) and labial inclined lower central incisors are strongly associated with thin GPh. BOP is increased in thin GPh while thicker GPh has more pocket depths. Thin GPh predicts a thin antral-mucosal thickness and vice versa.* ***Clinical significance:*** *Determination of GPh during routine examination is likely to be crucial to overcome unwanted outcomes after several interventions, as nowadays, the aesthetic outcome following any dental procedure is being a trend and critical for both clinicians and patients' satisfaction.*

Keywords: Gingival Phenotype, Thick Gingival Phenotype, Thin Gingival Phenotype, Modifying Gingival Phenotype, I-PRF, Hyaluronic Acid, Peri-Implant Soft Tissue.

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الأهداف: يعتبر النمط الظاهري اللثوي (GPh) أو النمط الظاهري للثة والأنسجة الرخوة أمرًا بالغ الأهمية لاتخاذ القرارات أثناء تخطيط العلاج والنتائج الجمالية في العديد من مجالات طب الأسنان. الهدف هو جمع وتلخيص الأدبيات المهمة حول النمط الظاهري اللثوي (GPh). البيانات: تم جمع البيانات وفقًا لما يلي: عنوان المقالة وتصميم الدراسة والكلمات الرئيسية. **الطريقة**: البحث في قاعدة بيانات ميدلاين (PubMed) واستكمالها بالبحث اليدوي للوصول بشكل أفضل إلى النوع الأساسي والثانوي المهم من الدراسات. تم الإبلاغ عن نتيجة البحث من خلال مخطط تدفق PRISMA. **الخلاصة**: نظرًا لأن أحد عوامل الخطر الرئيسية للالتهاب حول الزرع هو التهاب اللثة حول الزرع؛ فإن التشخيص الدقيق لالتهاب اللثة حول الزرع في وقت استبدال الأسنان قد يمنع حدوث عيوب مخاطية لثوية أو انحسار بعد علاج اللثة وتقويم الأسنان. النمط الظاهري للثة له تباين بين الأفراد وداخل كل فرد؛ ويوجد التهاب الغشاء المخاطي اللثوي في الأضراس أكثر من الضواحك والقواطع، وفي الأسنان الفكية أكثر من الفك السفلي وأصبح تعديل التهاب الغشاء المخاطي اللثوي اتجاهًا من خلال استخدام حمض الهيالورونيك (HA) أو الفيبرين الغني بالصفائح الدموية القابلة للحقن (i-PRF) مع الوخز الدقيق كعلاج طفيف التوغل. ترتبط فئة الهيكل العظمي (الأول والثالث) والقواطع السفلية السفلية المائلة الشفوية ارتباطًا وثيقًا بالـ GPh الرقيق، ويزداد ضغط الدم في الجيوب الرقيقة بينما يكون للـ GPh الأكثر سمكًا عمق جيب أكبر. يتنبأ الغشاء المخاطي الغشائي الرقيق بسماكة الغشاء المخاطي الجيبي الانفي والعكس صحيح. الأهمية السريرية: من المرجح أن يكون تحديد درجة حرارة الجسم أثناء الفحص الروتيني أمرًا حاسمًا للتغلب على النتائج غير المرغوب فيها بعد عدة تدخلات، حيث أن النتيجة الجمالية بعد أي إجراء للأسنان في الوقت الحاضر أصبحت اتجاهًا وحاسمًا لكل من الأطباء السريريين ورضا المرضى.

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INTRODUCTION

The gingival phenotype has gained attention in several types of clinical and scientific fields as the evaluation of treatment efficacy is becoming more and more dependent on the soft-tissue esthetic.[1] In history, gingival phenotypes were reported as 'fat' and 'pronounced scalloped' gingival biotype.[2] Recently, in 2017, "World Workshop on the classification of periodontal and peri-implant diseases and conditions" clarified the GPh as three dimensional gingival volume that includes gingival thickness (GT) and keratinized mucosal width (KMW) as these also parts of periodontal phenotype (PP) and It includes the thickness of the buccal/labial bone plate in addition to the gingival phenotype,[3-5] however, (Cortellini and Bissada, 2018) reported the GPh as a novel term in the new classification of periodontal and peri-implant diseases and conditions.

The last few years, There has been a lack of clarity about gingival entity and character for each individual. the outcome of several interventions are affected by GT such as; mucogingival therapy[6], guided tissue regeneration[7], implant dentistry[8], crown lengthening[9]. Therefore Understanding the gingival phenotype is a crucial component of treatment planning, clinical result prediction, and the selection of several dental procedures, including as implant placement, periodontal therapy, and orthodontic therapy[10-14], furthermore; a precise determination of high-risk individuals based on the thickness of their soft tissues; this emphasizes the necessity of a precise diagnosis[1]. Dental interventions are strongly correlated with PP; Patients with a thin phenotype are more likely to experience significant gingival recession following orthodontic, periodontal, or implantation treatments, whereas those with a thick phenotype are more prone to develop periodontal pockets,[15] nonetheless, different GPhs may react to orthodontic, periodontal, surgical, and restorative treatments in various ways[16-22]. The aim of this review is to summarize as much as possible of the crucial and new available literature and taking into consideration the mucosal phenotype upon more than one aspect in dentistry.

METHODS

The study was conducted in accordance to the preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (PRISMA)[23], and it is modified for better understanding the search results and facilitating the reproducibility. Figure1

Electronic search conducted by using the Medline database (PubMed) and complemented by manual searches of relevant and crucial articles representing review papers and original research. The following search term were applied: (Thick gingival phenotype) and (Thin gingival phenotype) from 1st of January 2000 to 24th of June 2024. No restrictions were applied. Because the criteria for the methodology of the included studies were wide, data from case series to experimental pre-clinical and clinical trials have been included for this review. Due to the narrative form of this review, no evidence-based quality assessment of the included studies was carried out. Owing to the heterogeneity of the data no statistical analysis was performed.

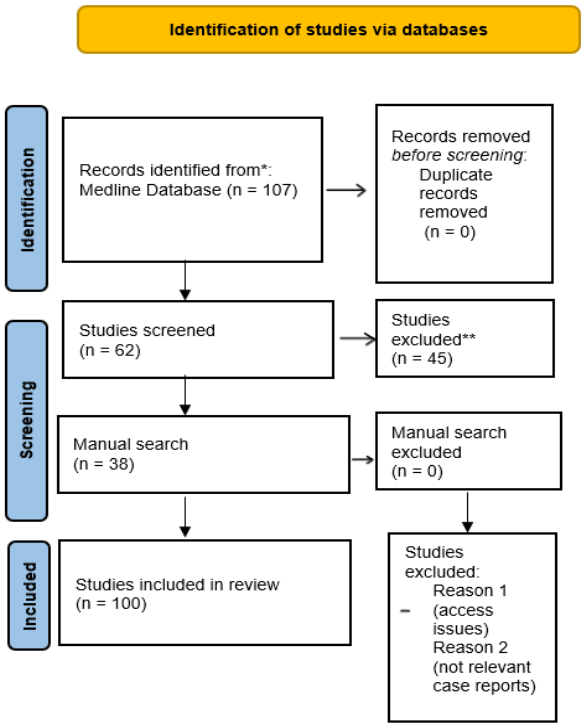

Figure 1. PRISMA-flow diagram.

Gingival phenotype distribution

To the best of the my knowledge, the distribution of GPh in both upper and lower jaws has only been studied once, in (Fischer, et al 2021) paper; which revealed that only seven out of the 56 patients had a similar GPh on all of their index teeth, meaning that only thin or thick distribution in the same patient: Five subjects; three males and two females exhibited a uniform, continuous thickening, whereas the two females had a continual thin phenotype, GPh: Premolars (61.6%; p = 0.09) and incisors (70.5%; p = 0.046) were primarily classified as thin, but most of molars (94.6%; p = 0.006) displayed a thick GPh. Furthermore, maxillary teeth generally showed much thicker GPh (p = 0.001), with no gender differences (p = 0.722). It is inaccurate when assessing a patient's GPh using the crown width/crown length (CW/CL) ratio of both upper central incisors, the ideal phenotype is assessed for every tooth. There is An impressive finding of a study revealed that the GPh was distributed according to anatomic locations, more prevalence of thin GPh was found in the mandibular posterior area [24].

Assessing methods of gingival phenotype

Kan et al, developed the use of a periodontal probe for the clinical assessment of GPh, offering a simple and affordable method. A number of techniques have been suggested, such as ultrasonography, color-coded probe or periodontal probe visibility, and transgingival probing with a needle or periodontal probe. Both the ultrasound and the transgingival measurement using a periodontal probe introduced results that were sufficiently reliable in every day practice[20]. Furthermore, the probe transparency approach is the most often utilized way to ascertain the thickness of the gingival phenotype[25], but when a dentist uses a color-coded periodontal probe, there's a potential they won't be able to distinguish between thick and very thick phenotype[26].

With the PCP 12 periodontal probe, it was discovered that the soft tissue thickness range for identifying the change from a thin to a thick GP was between 0.4 and 0.5 mm[27]. Labial Gingival dimensions of the mandibular anterior teeth were effectively recorded by dental MRI and superimposed CBCTs, with clinically acceptable variations[28]. On the other hand, measuring gingival thickness in the maxillary anterior teeth, CBCT is a more accurate and practical procedure than transgingival probing. When considering a treatment plan, the GPh may be determined with the use of Cone-Beam Computed Tomography / Computer-Aided Design and Prosthetic-Driven Implant Planning Technology,[29] because when visually assessing the GPh there will be an exaggeration of the thickness according to (Bartoszek, et al 2023) in a comparison with ultrasound measurement, which revealed that (86.81%) of the cases were diagnosed as thick GPh and classified as a thin GPh based on ultrasound. furthermore, it is not possible to use gingival height to predict gingival thickness.[30]

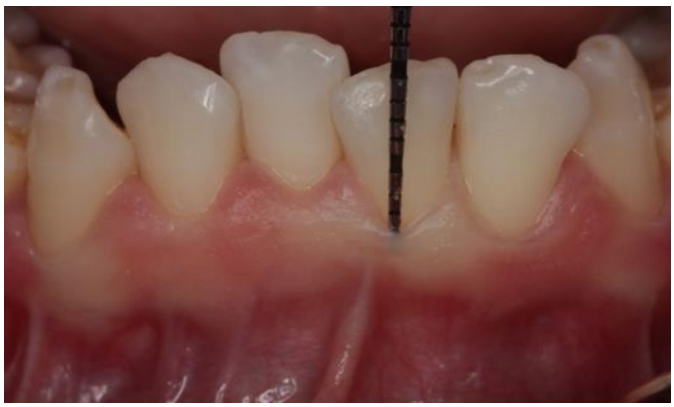

Figure 2. Transgingival probing by UNC periodontal probe to evaluate gingival thickness according the transparency by inserting the probe mid-facially 1mm deep into the sulcus. *(Figure from: Kloukos D, Roccuzzo A, Staehli A, Koukos G, Sculean A, Kolokitha OE, Katsaros C. Assessment of gingival translucency at the mandibular incisors with two different probing systems. A cross sectional study. Clin Oral Investig. 2024 Jun 28;28(7)) "Licensed under CC by 4.0"*

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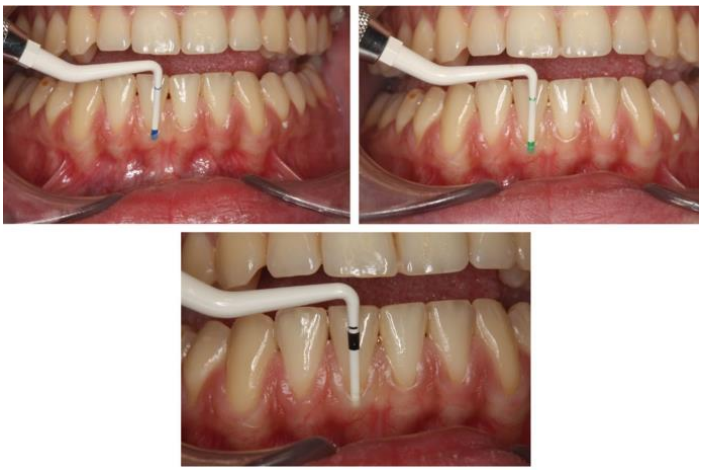

Figure 3. white, green, and blue color-coded periodontal probe introduced into the sulcus mid-facially by 1 mm. Visibility of the white color represents a thin GPh, green a medium GPh and blue a thick GPh. When none of the colors are visible the phenotype is classified as very thick GPh. (Figure from: Kloukos D, Roccuzzo A, Staehli A, Koukos G, Sculean A, Kolokitha OE, Katsaros C. Assessment of gingival translucency at the mandibular incisors with two different probing systems. A cross sectional study. Clin Oral Investig. 2024 Jun 28;28(7)) "Licensed under CC by 4.0"

Gingival thickness threshold

Gingival thickness of 0.7 mm was linked to gingiva translucency and at 0.8 mm of GT, a non-visible probe was detected by (Frost, et al 2015) with consideration of Probe visibility assessment may likely be affected by gingival pigmentation level. That means gingiva become transparent at thickness of 0.7mm or less and at 0.8mm probe is initiating to be invisible through the gingival margin.[1, 31] The probe's inability to distinguish between thin and thick phenotypes in marginal cases with mean values ranging from 0.53 to 0.62 mm.[32] (Kaya et al.) classified a GT of <1 mm and >1 mm as thin and thick phenotype.[33]

With the PCP 12 periodontal probe, it was discovered that the soft tissue thickness range for identifying the change from a thin to a thick GPh was between 0.4 and 0.5 mm.[27] Nevertheless, a cluster analysis by (de Araújo, et al 2020) found that (0.4mm-0.9mm) is a thin GPh, (1.0-1.3) is an intermediate GPh and (1.3-1.8) is a thick GPh.[34] Nonetheless, an universal threshold values have not yet been proposed, as several studies showed that the cut-off value is 1mm[17, 35] and other authors proposed that the threshold with 1.5mm.[36] Furthermore, several studies concluded that visible probe is available when gingiva is thin and ≤1 mm and more than 1 mm will be considered as thick and the probe will not be visible.[5, 17, 37]

Orthodontic approach

In patients, especially children, in need of dental care, gingival phenotypic assessment ought to be an ongoing component of the dental examination process. It is possible to take preventive action when thin gingiva is occurred, which raises the risk of periodontal issues, Orthodontic therapy should be implemented after a thorough phenotypic examination, as this allows for the identification of patients at risk of gingival recession.[38] Patients with the thin GPh need special care because labial tooth displacement might cause fenestration or bone dehiscence, which can look as a recession.[33] Because the thin GPh is more likely to develop recession, orthodontic treatment needs to be carefully planned.[18, 39] Though there are many data on the periodontal phenotype in the literature, nevertheless, very few of them are specific to children.[40, 41]

For the left mandibular central incisor, there is a strong correlation (P =.0183) between thin GPh and skeletal Classes I and III.[42] furthermore, protruded mandibular central incisor has significant association with a thin GPh[43, 44].

Adults have a lower incidence of gingival and bone remodeling than teenagers. In the case of thin-phenotype adult patients, Following the lingual movement of the teeth, bone and gingiva may not develop on the labial side of the teeth in a timely manner.[45] Furthermore, after extensive orthodontic movements, people with thin GPh may respond poorly and be more likely to develop gingival recession[33, 46].

CGF and PAOO

Patients having skeletal abnormalities frequently have a thin gingival phenotype leading to gingival recession following Periodontally Accelerated

Osteogenic Orthodontics (PAOO), therefore; Concentrated Growth Factor (CGF) may prefer soft tissue augmentation and enhances bone regeneration, that will substantially increase gingival thickness without post-op pain and bleeding complications of utilizing CTG instead of CGF[47, 48].

GPh and facial morphology

Patients who exhibited the Mesoprosopic facial phenotype were three times more likely to have a thin GPh than those who did not. This relationship between the facial phenotype and the GPh was significant, furthermore; Wider faces were linked to a higher probability of displaying the thin GPh[49].

Early transitional dentition Period

Periodontal soft and hard tissues go through changes during the child's period of time.[50] The morphological structure of the periodontium undergoes notable alterations, and GPh also undergoes changes.[51] Because of the gingiva's physiological thinning, the transitional phase between the primary and secondary dentition appears to be a critical time.[38, 41, 50] When the permanent incisor that replaced the primary tooth, and fully erupted throughout the observation period, the gingival thickness reduction was higher. Though there is much data on the periodontal phenotype in the literature, nevertheless, very few of them are specific to children.[40, 41] Gingival recession is 18% common during the developing stage and mostly affects the lower permanent incisors.[52] Also, an average gingival thickness reduced in mandibular incisors by 0.03mm and 0.63mm in attached gingival width was revealed by (Kus-Bartoszek et al.) in the early 2-year transitional dentition period, and after permanent tooth eruption the gingiva is gradually thickening.

Periodontal Approach

Baseline parameters

The majority of tooth-related variables are linked to gingival thickness. Thin GPh increases the likelihood of bleeding with controlled pressure on periodontal probe. This is consistent with findings from several articles regarding periodontal probing depth; shown that individuals with a thick periodontal phenotype had higher mean periodontal probing depths on average. KMW, female, and Lateral incisor may be risk factors for the thin periodontal phenotype.[21, 53, 54] Also, the following may be risk factors for labial dehiscence: age, canine, male sex, mandible, thin labial bone thickness, and root positioned against the labial plate. Risk factors for labial fenestration may include female, thick phenotype, root positioned against the labial plate, Lateral incisor, and Canine.[55] Patients with excessive gingival display and cigarette smokers seem to be linked to a thick gingival phenotype, furthermore; it is not possible to use gingival height to predict gingival thickness.[30]

The average of pocket depth (PD) in implants with ≥2 mm keratinized mucosal width was 0.5 mm. Interestingly, plaque index (PI) ratings were lower for implants with thick phenotypes.[24] While a thin GPh is friable and more likely to experience gingival recession after mechanical or surgical treatment, a thick phenotype is more resistant and more likely to create pockets.[39, 56]

Peri-implant dentistry

A method for consistently assessing the soft tissue's aesthetic quality surrounding single-tooth implant crowns is the Pink aesthetic score (PES).[57]

Peri-implant soft tissue height and thickness was evaluated by (Chu, et al) and suggested that the soft tissue height and thickness were 1.0 mm higher at regions with bone graft and interim restoration than at sites without either procedure at the time of immediate implant insertion.[58]Furthermore, guided bone regeneration (GBR) with combination of immediate implant placement in a post-extraction alveolus could be a good choice for preserving Bucco-lingual/palatal alveolar bone dimensions in aesthetic area. Which was not statistically significant between thin or thick GPh.[59]

The function of peri-implant soft tissues and their impact on implant health have gained significant attention in recent years.[60] The soft tissue around dental implants differs significantly from the soft tissue surrounding teeth, anatomically and histologically Collagen fibers in implants run parallel to the implant surface but are not directly anchored; this fragile connection results in a deficient biologic seal.[61]

Several studies show that better soft tissue health is correlated with sufficient KMW (>2 mm) surrounding implants.[62, 63] It has been demonstrated that inadequate KMW (<2 mm) around implants increases vulnerability to plaque-induced peri-implant tissue damage.[64, 65] Moreover, discomfort during home care has also been linked to insufficient KMW at implant regions (<2 mm); this has been explained by the mechanical irritation brought on by the non-keratinized mucosa's movement during function.[66]

As a result, significant risk factors for the development of peri-implantitis and peri-implant mucositis include both thin GPh and insufficient KMW.[24, 67] Furthermore, earlier research has linked elevated proinflammatory mediators to implant locations with insufficient KMW (<2 mm), and build-up of plaque.[68] In addition, Comparing implants with insufficient KMW to implants with sufficient KMW, insufficient KMW showed more food impaction, comparing implants with thick GPh and acceptable keratinized mucosa (KM) with thin GPh and inadequate KMW, the thick GPh showed less pain and discomfort during dental hygiene, which is substantially lead to food impaction there were no statistical differences in bone loss between the two types of phenotypes and KMW.[24, 66] (Garpure A, et al.) revealed that implants with thin GPh and insufficient KMW had a greater incidence of peri-implantitis and peri-implant mucositis. Implants with thin GPh were linked to a 3.32 higher incidence of peri-implantitis and 1.8 increased prevalence of peri-implant mucositis after adjusting for a number of confounding variables. implants with insufficient KMW were linked to 1.87 higher rates of peri-implant mucositis and 1.53 higher rates of peri-implantitis. As a result, thin GPh and insufficient KMW are important risk factors for peri-implant mucositis and peri-implantitis[24].

Marginal bone around implant

According to certain studies, the marginal bone is protected by utilizing an abutment that is more than 2-3 mm tall rather than by having thick mucosa.[69, 70] The current clinical belief is to place implants in sites with thick and adequate keratinized mucosa, regardless of whether these conditions are naturally present or surgically enhanced, as the majority of studies realize that thin vertical and horizontal mucosal phenotypes and a lack of keratinized mucosa elevate the risk of peri-implant diseases.[71-73] several studies reported that thicker GPh is modifying the bone remodeling and consequently preserve marginal bone loss[74-78] and in thin phenotype, soft tissue augmentation is used around bone level implants; radiographic bone loss is substantially reduced as opposed to non-grafted areas.[75]

Open flap debridement (OFD)

In patients with chronic periodontitis, periodontal phenotype is a significant factor impacting the outcome of OFD. A greater proportion of sites associated with thick PP (31.44%) exhibit attachment gain of more than 2 mm in comparison to those associated with thin PP (20.08%). Particularly in pockets with PD ≥7 mm, periodontal phenotype has a significant role in determining the clinical results of open flap debridement.[79] Better attachment gain was found by (Baldi et al.)[6] in gingiva that was more than 0.8 mm thick following a coronally advanced flap. Following crown lengthening surgery, patients with thick GPh experienced more coronal soft tissue rebound than those with thin GPh, according to (Arora et al.) In a crown lengthening intervention, a higher incidence of gingival shrinkage was observed in thin scalloped gingiva.[80] Recession of 0.31 mm in thin PP and 0.33 mm in thick PP was noted six months after surgery in (Gumber et al.)[79], which is in line

with the gingival margin's postoperative change after modified Willman flap surgery.[81]

Coronally advanced flap (CAF)

It has been suggested that gingival phenotype impacts whether or not a soft tissue graft is required in addition to CAF, the presence of gingiva thicker than 1.2 mm, it has been shown that there is a greater likelihood of achieving complete root coverage (CRC) with CAF alone; under these circumstances, adding a graft in locations where there is already a thick GPh may be considered as "overtreatment."[82]; so, patient's morbidity and the risk of postoperative complications which are often associated with the palate donor site are decreased when soft tissue grafts are avoided when they are not necessary.[83] One important component influencing CAF alone results is GPh. Those with medium, thick, or very thick GPh had similar outcomes (83.3% to 94.3% of mean root coverage (mRC), on average), while those with thin GPh showed the lowest mRC (60.3%).[84]

Eventually, the baseline of Gingival thickness is crucial when performing Coronally advanced flap for gingival recession either in the single or multiple form,[85, 86] Also the baseline of gingival thickness of less than or equal to 0.82mm a higher Root coverage aesthetic score when performing CAF and CTG compared to baseline of more than 0.82mm when CAF alone was performed but with better aesthetic score.[87] Subsequently, the very thick and thick GPh produced better clinical and aesthetic outcomes and that a tunnelling technique could potentially be practical under these conditions, without a connective tissue graft (Rasperini et al., 2019)

Modifying the Gingival phenotype

The dependable way to alter the gingival phenotype is to add soft tissue graft (Cortellini & Bissada, 2018).

The impact of HA & i-PRF on GPh

Numerous critical biological processes, including angiogenesis, wound healing, regeneration, mitosis, cell adhesion, motility, differentiation, and proliferation, are influenced by hyaluronic acid HA[88] as well as injectable-platelet rich fibrin (i-PRF) shows the ability to include many growth factors (GF) that promote tissue regeneration and can activate fibroblast activity.[89] So, in thin gingival phenotypes, repeated injections of HA or i-PRF led to an increase in GT.[90] Another study reported that there is a statistically significant elevation in GT when introducing i-PRF with Microneedling compared with i-PRF alone.[91, 92]

Antral-mucosal thickness

Gingival phenotype and sinus mucosal thickness are closely related, (Aimetti, et al. 2008) revealed that individuals having 1.26 ± 0.14 mm (0.95 to 1.40 mm) Schneiderian membrane thickness is correlated with thick GPh and thin GPh is associated with (0.45mm to 0.85mm) and 0.61 ± 0.15 mm of Schneiderian membrane thickness, that seems to be the GPh is a dependable parameter to anticipate sinus membrane thickness.[93]

Tooth morphology and gingival phenotype

Historically, the association between a thick GPh and a square tooth form, and a "scalloped and thin" GPh and a tapering tooth form, was originally demonstrated by (Ochsenbein and Ross),[2] and numerous investigations have demonstrated a relationship between GPh and tooth morphology.[94-96] Identical gingival phenotype assessment leads to satisfied functional and aesthetic outcomes, it is a crucial step for a thorough treatment plan.[97] Placing the Periodontal probe in the labial sulcus is a simple way to evaluate the GPh.[8] Many studies revealed that narrower and longer crowns with higher papilla height (PH) is linked to a thin gingival phenotype, on the other hand; shorter, wider and lower PH is linked to a thick GPh.[98-100] More simply described, triangle-shaped teeth were associated with a scallop-shaped gingiva(thin GPh) and square teeth were connected to a flat gingiva (thick GPh).[97] In addition description; the long proximal contact area of the squared teeth reflects positively on the reduction of

black triangle appearance.[101] Last but not least; Research conducted in Yemen found a high correlation between GT and WKG, the (CW/CL) ratio, and papilla height.[51]

CONCLUSION

As one of the major risk factors of peri-implantitis and peri-implant mucositis is GPh; Careful diagnosis of GPh at the time of tooth replacement may prevent from developing mucogingival defects, or recession following periodontal and orthodontic treatment. Gingival phenotype has inter-individual and intra-individual variations, thicker GPh is presented in molars rather than premolars and incisors, and in maxillary teeth rather than in mandibular. Skeletal class (I and III) and labial inclined lower central incisor are strongly associated with thin GPh.

BOP is increased in thin GPh while thicker GPh has more pocket depth. Thin GPh predicts a thin antral-mucosal thickness and vice versa. Thick GPh showed less pain and discomfort during dental hygiene. Shorter and wider teeth with low PH are associated with thick GPh while longer and narrower crowns with high PH are associated with thin GPh.

Modifying GPh is becoming a trend through the use of HA or i-PRF with microneedling as a minimally invasive therapy. Eventually, determination of GPh during routine examination is likely to be crucial to overcome unwanted outcomes after several interventions as nowadays, the aesthetic outcome following any dental procedure is being a trend and critical for both clinicians and patients' satisfaction.

Competing interest

The author declares that he has no competing interests.

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