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Review

Soft tissue conditioning around teeth: A narrative review

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ABSTRACT

Mucogingival surgery encompasses any procedure designed to correct defects in the morphology, position, or enhance the dental gingival junction. The lack of keratinized gingiva and the presence of gingival recession can be an esthetic and functional problem for the patient. This paper will review the gingival dimensions of the periodontium in health and address the prevalence, etiology, and predisposing factors related to defects in the quality and quantity of gingiva.

Gingival augmentation techniques and indications will be reviewed, including root coverage and non-root coverage procedures. Autogenous soft tissue grafts will be described, as well as several non-autogenous graft materials.

Ultimately, careful diagnosis, realistic expectations, clear goals, and correct technique selection are essential for the most successful clinical results.

1. Introduction

Mucogingival surgery encompasses any procedure designed to correct defects in the morphology, position, or enhance the dental gingival junction [1].

In the mid-1950s, *Friedman* [2] introduced the concept of *mucogingival surgery* as "*surgical procedures utilized to resolve problems involving the interrelationship between gingiva and alveolar mucosa, such as pockets extending apical to the mucogingival junction, malpositioned frena, and inadequate vestibular depth.*" [2–4].

As new periodontal surgical concepts and techniques were developed, a new and broader definition was needed to include these new approaches. *Miller 1988* [5] coined the term Periodontal Plastic Surgery, which he defined as *"surgical procedures performed to correct or eliminate anatomic, developmental, or traumatic deformities of the gingiva or alveolar mucosa."*

A broader term, *Mucogingival Therapy*, was later introduced and described as "*non-surgical and surgical correction of a defect in morphology, position, and/or amount of soft tissue and underlying bone* [6]. Therefore, mucogingival therapy includes [6,7]:

- Root coverage
- Ridge augmentation
- Maintenance of ridge form following extraction of periodontally involved teeth
- Crown lengthening/correction of excessive gingival display (gummy smile)
- Exposing teeth for orthodontic movement
- Maintenance and/or reconstruction of interdental papilla
- Removal of aberrant frenulum
- Periodontal-prosthetic corrections
- Mucogingival and esthetic surgical corrections around implants

This paper will discuss both gingival augmentation without root coverage and root coverage procedures.

2. Gingival dimensions

2.1. Gingival phenotype

Phenotype [8] is defined as the observable characteristics or traits of an organism that are produced by the interactions of the genotype and the environment (its expression includes the biotype). On the contrary, *biotype* [9] is defined as a set of organisms sharing a specified genotype.

The term periodontal biotype was first proposed by *Seibert & Lindhe 1989* [10] to designate distinct features ("flat-thick" or "scalloped-thin") of the periodontium, including the underlying alveolar bone [11]. The

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Fig. 1. Visual comparison of a thick (top picture) vs a thin (bottom picture) gingival phenotype.

Fig. 2. Clinical diagnosis of a thin gingival phenotype, note the visibility of the periodontal probe through the tissues (left picture), and a thick gingival phenotype, note how the probe is not visible through the tissues (right picture).

concept has been labeled by different authors as gingival/periodontal "biotype," "morphotype," or "phenotype." [12].

The systematic review *by Zweers* et al. *2014* [13] classified the "biotypes" into three categories:

- *Thin scalloped*, associated with slender triangular-shaped crown, subtle cervical convexity, interproximal contacts close to the incisal edge and a narrow zone of keratinized tissue (KT), clear, thin, delicate gingiva, and a relatively thin alveolar bone.
- *Thick flat*, associated with square-shaped tooth crowns, pronounced cervical convexity, large interproximal contact located more apically, a broad zone of KT, clear thick, fibrotic gingiva, and a comparatively thick alveolar bone.
- *Thick scalloped*, showing a clear, thick fibrotic gingiva, slender teeth, narrow zone of KT, and a high gingival scallop. (*See* Fig. 1)

The 2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions suggested the adoption of the definition *"periodontal phenotype"* [11] to describe the combination of *gingival phenotype* (three-dimensional gingival volume) and *bone morphotype* (thickness of the bone plate) [14].

This updated term reflects the fact that the phenotype may change over time, depending on clinical intervention and environmental factors, and can be site-specific.

The gingival phenotype is assessed clinically by using a periodontal probe to measure the gingival thickness [15,16]. If the periodontal probe is visible through the gingival tissues, the site is classified as having a thin gingival phenotype (≤1 mm). If the probe is not visible through the tissues, the site is classified as having a thick gingival phenotype (>1 mm). (*See* Fig. 2).

The identification of the gingival and periodontal phenotype may be clinically relevant as it may affect the development and/or progression of marginal tissue recession [17–20]. Identifying the phenotype may also affect treatment outcomes in situations where periodontal hard and soft tissues are involved (e.g., root coverage, crown lengthening, implant placement, orthodontic treatment, restorative treatment, etc.).

2.2. *The need for keratinized tissue*

In the 1950s, authors and researchers recognized the need for keratinized tissue (KT) and believed that it was always required to ensure healthy gingiva [2,22,23]. The belief was that a band of attached gingiva would serve as a barrier to protect the gingiva against the functional stresses produced by mastication and toothbrushing [24–26]. Several

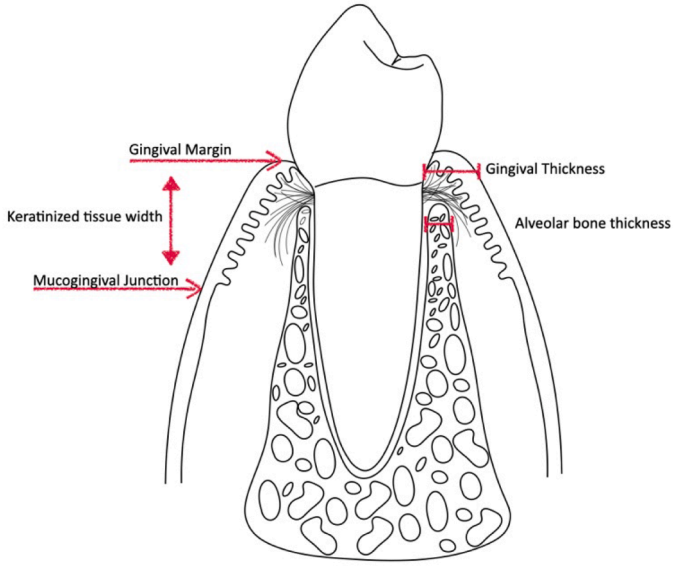

Fig 3. Components of the periodontal phenotype (adapted from *Avila-Ortiz* et al. *2020* [21].

Fig 4. Recession on the mandibular incisors, with minimal keratinized tissue, no attached gingiva & high frenulum attachment.

subsequent studies have analyzed the amount of KT around teeth in order to determine what should be considered sufficient attached gingiva [27,28]. It was not until *Lang & Löe 1972* [29] published a seminal study of 32 dental students relating the amount of attached gingiva to signs of clinical inflammation and health. The study showed that despite having all tooth surfaces free from plaque, areas with <2 mm of gingiva exhibited clinical signs of inflammation. Based on their observation, the authors suggested that 2 mm of KT (corresponding to 1 mm of attached gingiva) was adequate to maintain clinical health. However, subsequent publications failed to fully corroborate that concept. In fact, these publications concluded that it was possible to maintain a clinically healthy gingiva despite a very narrow or absent zone of attached gingiva, provided good, atraumatic oral hygiene was performed [27,30–33]. They also confirmed that when adequate plaque control was carried out and no clinical signs of inflammation were present, no attachment loss would occur, irrespective of the amount of gingiva. In addition, several prospective studies demonstrated that the incidence of soft tissue recession was not greater at buccal surfaces with

Fig. 5. Thin gingival phenotype, lack of keratinized tissue, shallow vestibulum, and high frenulum attachment as factors associated with the etiology of a recession.

a narrow/absent band of attached gingiva as compared to surfaces with a wide band [33–35].

Therefore, based on the current scientific evidence, minimal or no attached gingiva can be compatible with periodontal health and gingival margin stability. Nevertheless, there may be some scenarios related to suboptimal plaque control or restorative needs where the patient would benefit from having a band of KT/attached gingiva. However, no recommendation on an "adequate" amount of gingiva can be suggested.

2.3. Marginal tissue recession

Marginal tissue recession (or gingival recession) is defined as the apical shift of the gingival margin in relation to the cementoenamel junction (CEJ); it is associated with attachment loss and exposure of the root surface to the oral environment (Figs. 3 and 4). Although the etiology of gingival recession remains unclear, several predisposing factors have been suggested [1,12,14].

2.3.1. Prevalence

Gingival recession is a very prevalent condition affecting populations with high standards of oral hygiene [36–38] as well as populations with deficient oral hygiene [36,39,40].

Studies reporting the prevalence of gingival recession have shown that 6 – 100% of patients exhibit soft tissue recession, with prevalence highest in older cohorts of patients [41–49]. However, despite older patients exhibiting a higher prevalence of gingival recession [41,42,44], it is not considered a consequence of aging. [50].

Additionally, *Albandar & Kingman 1999* [44] found that gingival recession is more prevalent in male subjects and the African-American population as compared to other racial/ethnic groups. The most prevalent sites were maxillary first molars, followed by mandibular incisors.

2.3.2. Etiology

The exact etiology of gingival recession remains unclear. Numerous authors have tried to address the possible etiologic causes of gingival recession, and the current consensus is that the etiology seems to be multifactorial, with several predisposing factors possibly playing a role (Fig. 5) [12,51].

Tissue trauma caused by vigorous and aggressive toothbrushing is generally accepted as the predominant etiologic factor for the development of recession [17,50,52–54]. Trauma from improper oral hygiene devices, parafunctional or factitious habits, as well as intraoral and perioral piercings have also been associated with soft tissue recession (Fig. 6) [52,55–59].

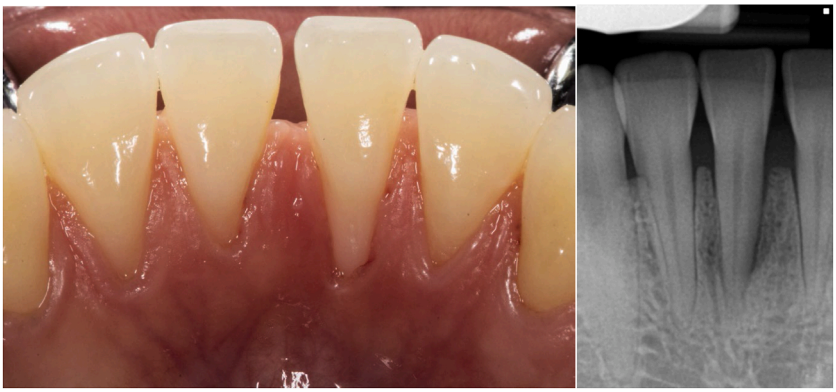

Fig. 6. Left: Recession of 4 mm in the lingual aspect of tooth #25 on a patient with tongue piercing; Right: peri-apical radiograph showing radiolucency around the root of tooth #25.

A systematic review by *Kim & Neiva 2015* [18] found that sites with minimal or no KT and subgingival or intra-crevicular restorative margins are more prone to inflammation and gingival recession.

Orthodontic tooth movement has also been associated with soft tissue recession. The direction of the tooth movement and the buccolingual thickness of the gingiva play an important role in the apicocoronal displacement of the gingival margin [18,60]. Nevertheless, the evidence is equivocal since some researchers could not find a direct association between orthodontic movement and gingival recession [61, 62]. Therefore, it appears that if the tooth is displaced outside the bony envelope of the alveolar process, and there is a thin periodontal phenotype in addition to other predisposing factors, there may be a higher chance of developing gingival recession.

Thin gingival phenotype and bone morphotype, as well as lack or minimal KT are also considered risk factors for the development of gingival recession [12,13,17,18].

There is a group of conditions that, despite minimal evidence, have been claimed to contribute to the development of gingival recession. Those include but are not limited to clinically detectable plaque, persistent gingival inflammation/bleeding on probing, frenum position problems, occlusion, tobacco, history of periodontal disease/recession, soft tissue clefts/deformities, shallow vestibular depth, diabetes and herpes simplex virus [12,51,63,64].

The possible consequences of gingival recession include impaired aesthetics, dentin hypersensitivity, and caries/non-carious cervical lesions (NCCL), all possibly leading to different degrees of loss of function [14,49].

2.3.3. Diagnosis

Once the presence of true gingival recession has been identified, it should be classified according to a treatment-oriented recession classification.

Miller 1985 [65] described a classification of recession defects taking into consideration the anticipated root coverage that is possible to obtain with the use of a free gingival graft:

- *Class I*: Marginal tissue recession not extending to the mucogingival junction; no loss of interdental bone or soft tissue. 100% root coverage can be anticipated.
- *Class II*: Marginal tissue recession extending to or beyond the mucogingival junction; no loss of interdental bone or soft tissue. 100% root coverage can be anticipated.
- *Class III*: Marginal tissue recession extending to or beyond the mucogingival junction; loss of interdental bone/soft tissue or malpositioning of the tooth. Partial root coverage can be anticipated.
- *Class IV*: Marginal tissue recession extending to or beyond the mucogingival junction; severe loss of interdental bone/soft tissue or severe malpositioning of the tooth.

Despite the widespread use of the Miller classification, it had several limitations, such as the difficulty in distinguishing between Class I and II, and the use of "bone or soft tissue loss" as the interdental reference to diagnose periodontal loss of attachment in the interdental area [12,66]. For that reason, the 2017 World Workshop incorporated the use of a more modern recession classification based on the measurement of interdental clinical attachment level (CAL) to predict the final root coverage (Fig. 7): [67]

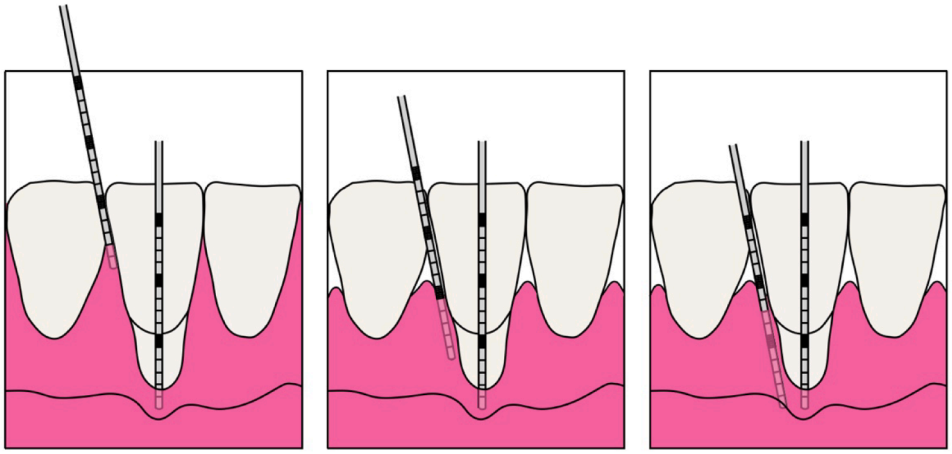

Fig. 7. Cairo classification of gingival recession. RT1 on the left, RT2 on the center, and RT3 on the right image.

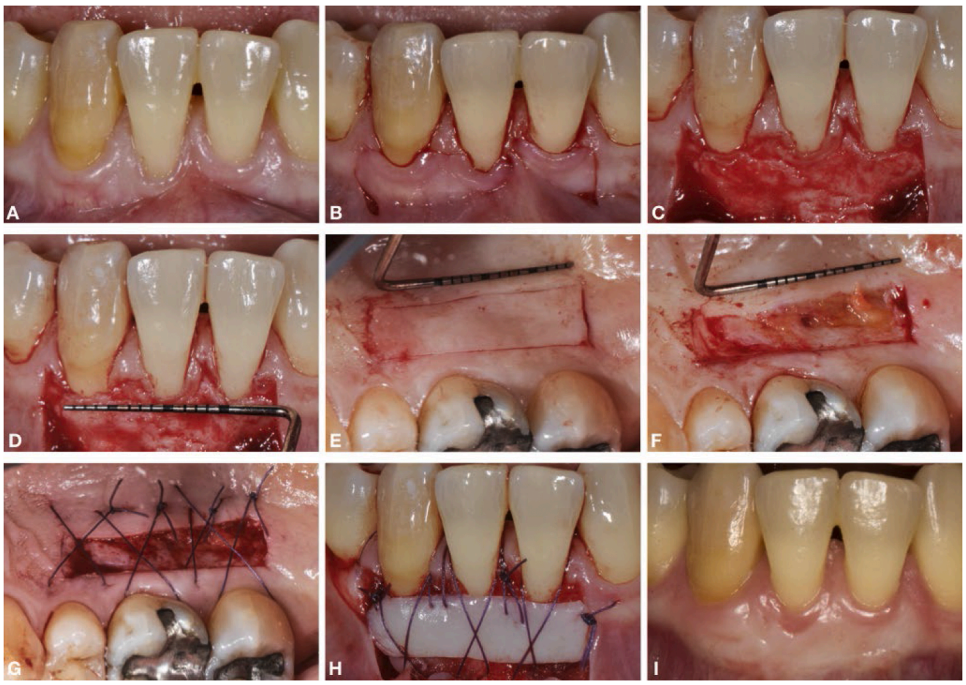

Fig 8. Epithelialized free gingival graft. (A) Pre-operative view. (B) Recipient bed preparation incision. (C) Recipient bed prepared. (D) Measurement of recipient bed. (E) Palatal graft outlined. (F) Palatal wound after graft is harvested. (G) Palate sutured. (H) Graft stabilized in recipient bed by simple interrupted and sling sutures. (I) Follow up at 18 months.

- *Recession Type 1 (RT1)*: Gingival recession with no loss of interproximal attachment.
- *Recession Type 2 (RT2)*: Gingival recession associated with loss of interproximal attachment less than or equal to the buccal attachment loss.
- *Recession Type 3 (RT3)*: Gingival recession associated with loss of interproximal attachment greater than the buccal attachment loss.

3. Gingival augmentation

Gingival augmentation procedures are those designed to increase the quantity of attached gingiva. [1] Such procedures encompass a series of different surgical techniques developed through the years to increase the quantity and quality of gingiva.

Subsequently, gingival augmentation procedures will be divided into non-root coverage and root coverage procedures.

3.1. Non-root coverage procedures

Non-root coverage gingival augmentation procedures are performed to facilitate plaque control, improve patient comfort, and prevent future recession. [19]

As mentioned earlier, the need for a specific amount of KT remains controversial. Therefore, the presence of a narrow zone of gingiva cannot justify surgical intervention. However, in patients with suboptimal plaque control, most clinicians will agree that ≥1 mm of attached gingiva is necessary to maintain periodontal health [33,68–70].

3.1.1. Indications

Based on available evidence, the following may be considered as indications for gingival augmentation procedures: [6,18,19,71]

- Presence of suboptimal plaque control and clinical inflammation
- Presence of patient discomfort during toothbrushing or chewing due to mucosal trauma
- Presence of gingival recession extending beyond the mucogingival junction with evidence of advanced interproximal bone loss
- Iatrogenic etiology such as:
  - Presence of intra-crevicular/subgingival restorative margins
  - Clasps from removable appliances
- Pre-orthodontic surgery in cases of specific anticipated tooth movement
- Pre-prosthetic surgery
- Other anatomic conditions (aberrant frenulum, high frenal attachment, shallow vestibule; if they are associated with gingival recession)

3.1.2. Contraindications

Dental contraindications for non-root coverage gingival augmentation surgery include hopeless or non-restorable teeth, active dental disease, including active caries, and periodontal or endodontic pathologies.

Conversely, patent-related contraindications that may compromise treatment outcomes or increase the likelihood of complications include uncontrolled medical conditions (such as diabetes, cardiovascular disease, coagulopathies, or immunosuppression) and medications that interfere with periodontal healing or excess bleeding. Notably, smoking has been shown to worsen outcomes in soft tissue augmentation surgery [72–74]. Additionally, controlling etiological factors at the site, including patient habits, is imperative before performing any soft tissue augmentation procedures.

Utilizing a soft tissue substitute is recommended for patients who are averse to having a secondary wound in the palate. Moreover, individuals with high esthetic demands may not accept treatment with an FGG or a graft substitute; therefore, a coronally advanced technique must be performed on those patients.

3.1.3. Surgical procedures

3.1.3.1. Gingival extension operations. The main goal of these procedures is to increase the amount of KT. Most of these techniques were

developed in the mid-1950s and 60 s and were performed on an empirical basis. *Goldman, Schluger,* and *Fox 1956* [75] described and discussed in detail the first techniques used to increase the zone of KT (i.e., "gingival extension operations"). These techniques developed as an extension of frenectomy and gingivectomy procedures. [2,22–24,76–78]. In these types of surgery, flaps are apically positioned, leaving the bone exposed to granulate in and heal by secondary intention. It was observed following surgery that areas previously covered with alveolar mucosa were instead covered with a band of KT. Based on that observation, vestibular extension operations became the favored option to increase the band of KT. The biological process behind that phenomenon was studied by *Karring* et al. *1971* [79], where it was suggested that granulation tissue proliferating from the supra-alveolar connective tissue and/or from the periodontal ligament would ultimately lead to the keratinization of the epithelium [79,80].

Gingival extension operations were then classified as either "bone denudation" procedures, where the bone was left exposed, or "periosteum retention" procedures, where the bone was left covered by periosteum [81,82]. Despite the latter being less aggressive, both techniques resulted in bone loss, gingival recession, and inconsistent gains of KT [26,81–86]. As a result, gingival extension procedures slowly lost popularity, especially after the introduction of a new surgical approach to increase the amount of KT: the epithelialized gingival graft.

3.1.3.2. Gingival grafting. The use of autogenous epithelialized gingival grafts (or "free gingival grafts" [FGG]) for periodontal therapy was first described by *Björn in 1963* [87] and subsequently by others [88–93]. The original concept involved harvesting a fully epithelialized gingival graft from the patient's palate and relocating it to a recipient site to increase the vestibular depth and width of attached gingiva and/or to correct frenum problems.

The main steps in the procedure are:

- **Preparation of the recipient bed**: Sharp reflection of a partial-thickness flap of the adequate dimension is performed. Once elevated, the flap will be apically sutured or excised. The recipient bed should be covered by a firm layer of periosteum protecting the underlying bone with the absence of muscle or frenal pulls/attachments (Fig. 8A-D).
- **Graft harvest**: Palatal sounding with a periodontal probe is recommended to identify the areas of adequate thickness. Usually, the area of the premolar region is advocated since it has the greatest thickness. The size of the graft should be based on the recipient bed and account for primary and secondary contraction. A shallow incision should be performed with a blade to delineate the dimension of the graft. Subsequently, the epithelialized graft should be harvested with sharp dissection. The thickness of the graft should be $\geq$ 1 mm to ensure that it will have an adequate amount of connective tissue to allow for graft survival [18]. Sutures may be placed on the palate, as well as the placement of surgical dressing or a prefabricated surgical stent (Fig. 8E-G).
- **Graft stabilization on recipient bed**: Once the graft is harvested, it may need to be trimmed or adjusted with surgical scissors or a blade. Next, the epithelialized graft will be placed on the recipient bed and stabilized with sutures, ensuring the graft does not show any mobility with normal lip movements. Simple interrupted sutures and sling sutures are commonly used. Slight pressure is recommended to ensure no blood clot forms between the graft and recipient bed. A surgical dressing may or may not be placed (Fig. 8H).
- **Suture removal**: Palatal sutures can often be removed after one week. Graft sutures will be removed after 1–2 weeks or even later, depending on the suture material selection.

Oliver et al. *1968* [94] were the first to investigate healing events after gingival grafting in the oral cavity at a microscopic level. Based on the examination of grafting in seven rhesus monkeys, they divided the healing of free gingival grafts into three phases:

1) **Initial phase of healing (0–3 days)**: Presence of a thin layer of fibrin between the graft and the periosteal bed. There is absence of blood vessels; therefore, the survival of the graft is through "plasmatic circulation" in which the exudate that spreads through the graft from the periosteal bed provides cellular nutrition. The epithelial layer will degenerate, with desquamation of the outer layers.
2) **Revascularization phase (4–11 days)**: The primitive cellular nutrition is rapidly replaced by a vascular system. There is presence of anastomoses between vessels of the graft bed and the pre-existing vessels in the graft. Fibroblast proliferation is observed between the periosteal bed and gingival graft. By the end of this phase, there is a dense fibrous union between the graft and the periosteum. After the initial desquamation of the epithelium, there will be a progressive re-epithelialization of the graft from cells persistent in the deepest portion of the epithelial ridges and adjacent tissues.
3) **Tissue maturation phase (11–42 days)**: Gradual reduction in the number of vessels. By the 14th day, the vasculature has assumed a normal pattern. Increase density and further orientation of the connective tissue fibers at the graft-bed interface. Increase in thickness of epithelium and epithelial ridges. Healing is virtually completed at 14 days.

Graft thickness will determine the graft behavior during healing. Thick grafts tend to have more primary contraction, that is, early contraction right after harvesting the graft, due to the elevated amount of elastic fibers within the graft. On the other hand, thinner grafts will exhibit less primary contraction but more secondary contraction (the one that occurs throughout the healing period) [93]. Although variable, graft shrinkage as much as 58% can be expected [95].

Other than graft shrinkage, another phenomenon related to the later stages of healing of free gingival grafts is *creeping attachment*. It is defined as the postoperative migration of the gingival margin in a coronal direction over portions of a previously denuded root [96]. It occurs during the second month after gingival grafting [97] and may continue for 12 months after surgery, although it does not seem to follow a consistent progression pattern [98,99]. Some reports have shown that creeping attachment may continue to progress beyond the first postoperative year [100–102].

3.1.3.3. Soft tissue substitutes. Most of the original techniques involved autogenous gingival grafting, which requires a second surgical site, potentially leading to additional comorbidities and discomfort for patients. Additionally, some patients may require grafting in multiple areas of their oral cavity and may not have sufficient tissue available to treat all these sites. To mitigate this, xenogeneic and allogeneic materials have been substituted instead of autogenic materials with varying degrees of success.

Acellular dermal matrix (ADM) is an allograft that has been extensively used. It is a freeze-dried, cell-free dermal matrix composed of a basement membrane and extracellular matrix from human donor skin. Its main components are elastic fibers and collagen bundles. The primary purpose of dermal grafts was to treat burn victims and other extraoral wounds, but they eventually became an option for use in the oral cavity [103–105]. However, despite the obvious surgical advantages (no second surgical wound, availability of tissue, time-saving), the increase in KT following the use of these grafts may not be as predictable compared to autogenous palatal grafts due to considerable shrinkage and inconsistent quality of the resultant attached tissue [106–109].

Xenogenic collagen matrices, composed of types I and III collagen and derived from porcine or bovine sources, have also been used for the same purpose [110–113]. Although safe for human use and with the

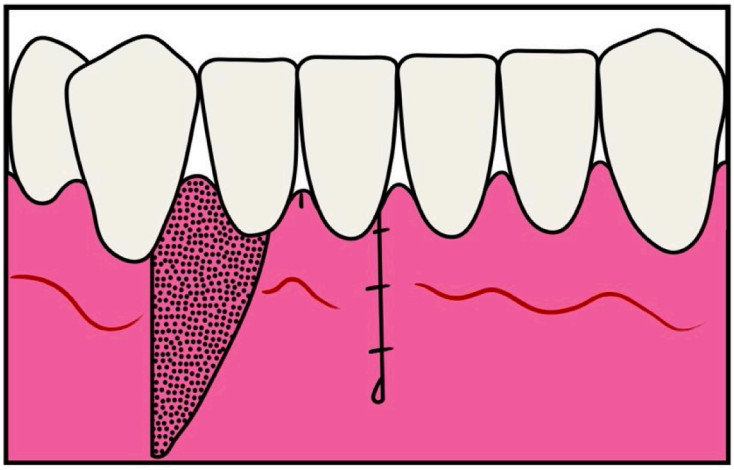

Fig. 9. Lateral sliding pedicle flap from *Grupe & Warren 1956* [127]..

same advantages as ADM, the increase of KT has been shown to be inferior to that achieved when using a FGG [109,110,113].

Nevertheless, soft tissue substitutes have been shown to increase KT in areas with reduced or minimal gingiva. Although promising, long-term follow-up studies and randomized controlled trials should be conducted to enhance and strengthen the evidence behind this surgical approach.

In conclusion, when gingival augmentation is warranted, while allogeneic and xenogeneic grafts present viable options, autogenous gingival grafts are considered the gold standard. The utilization of FGGs has consistently demonstrated a reliable and predictable increase in KT width.

3.2. Root coverage procedures

Root coverage procedures strive to achieve complete resolution of the recession defect, with minimal probing depths and good integration of color and texture with the adjacent soft tissue [114].

All etiologic and contributing factors should be identified and corrected prior to treatment planning the surgical procedure. The two major etiologic factors are toothbrush trauma and plaque-induced periodontal inflammation. The correction of those factors will prevent the progression of the recession. On the other hand, if those factors are not corrected, relapse of the recession may occur even after treatment.

The next step is to establish an accurate diagnosis of the recession defect(s) based on the buccal recession and interproximal attachment loss [67].

3.2.1. Indications

The main indications for root coverage procedures are esthetic demands and root sensitivity. Nevertheless, other situations may require root coverage, such as cases with unfavorable gingival margin contours, which can limit proper plaque control for the prevention of caries and potentially result in the development of non-carious cervical lesions (NCCLs) [114–118].

3.2.2. Contraindications

Dental and patient contraindications for root coverage surgical procedures align closely with those for non-root coverage procedures. The primary determinant in decision-making is the extent of KT available. In instances of inadequate KT, incorporating a soft tissue graft becomes necessary, while cases with sufficient KT may only require a coronally advanced flap. Additionally, factors such as vestibule depth and the quantity of tissue on neighboring teeth need consideration, especially when planning a lateral sliding flap [119,120]. Patients' preference regarding the avoidance of a palatal wound influences the choice between utilizing an autogenous graft or opting for a graft substitute.

3.2.3. Surgical procedures

Root coverage techniques have evolved throughout the years. The ultimate aim of technique modifications is to improve the chances for complete root coverage and simplify and minimize trauma to the tissues and morbidity for the patients.

The first cases described in the literature date from the first decade of the 1900s when attempts for root coverage were carried out "*by grafting a piece taken from behind the third molar of the same mouth*" [*Meeting December 1902 – Dr. Younger*] [121]. Other authors then reported positive root coverage outcomes by coronally advancing the gingival margin [122–125]. Although these techniques were considered groundbreaking at the time, they were abandoned for several decades and later reintroduced and modified [126].

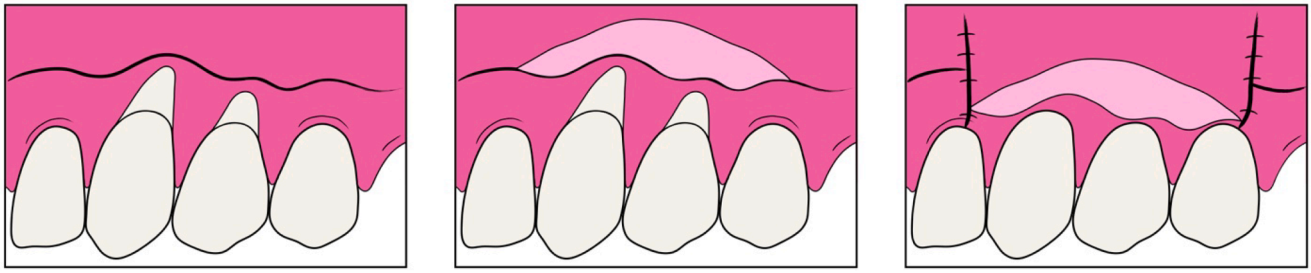

Fig. 10. Two-stage FGG from *Bernimoulin* et al. *1975* [136]. Note the lack of KT and gingival recession on the left image. An FGG has been done to increase the amount of KT. Note that no attempt was made to cover the root during the first stage (center image). After two months of healing, the flap with the healed FGG is coronally advanced using vertical releasing incisions to cover the denuded root surfaces (right image).

Fig 11. Subepithelial connective tissue graft. (A) Pre-operative view. (B) Connective tissue graft harvested from the donor site. (C) Recipient site prepared. (D) Recipient site sutured with connective tissue graft using the tunnel flap technique. (E) Post-operative result: 2 weeks. (F) Post-operative result: 6 months.

Grupe & Warren 1956 [127] described a method to cover an exposed root by laterally sliding a pedicle flap created from the adjacent gingiva. This approach was indicated in situations where there was an isolated recession defect next to an area with abundant gingiva. The adjacent KT flap was then displaced laterally to cover the exposed root, leaving the donor area healing by secondary intention (Fig. 9). Subsequent modifications to the technique, including the double papilla flap or the oblique rotated flap, were published to minimize trauma from the donor site, as well as to include multiple recessions and improve predictability for root coverage [128–134].

The main drawback of using only a pedicle flap from the adjacent tissues was that success was limited to those cases in which the adjacent tissues are thick and have an adequate band of KT. Unfortunately, only a small number of patients are candidates for these types of flaps alone. To improve the outcome, the use of a soft tissue autograft was suggested in order to increase the quality and quantity of the tissue thickness. *Harvey 1970* [*135*] initially and *Bernimoulin* et al. *1975* [*136*] reported a two-stage procedure, where at the first stage, a free gingival autograft was placed and allowed to heal for two months. Subsequently, in the second stage, the flap was coronally advanced. This technique established some of the current protocols for coronally advanced flap techniques (Fig. 10). Another approach suggested for covering a denuded root was the placement of a free gingival graft directly over the root surface [88–90,93,137–141]. Although both root coverage and an increase in KT and tissue thickness can be achieved, using this technique, success is limited by the height and width of the recession defect and the potential for an unesthetic result. Therefore, an approach that prioritizes esthetics and complete root coverage had to be introduced: the connective tissue graft (CTG).

The procedure of the subepithelial connective tissue graft became known through the techniques proposed by *Raetske* [142] and *Langer & Langer 1985* [*143*]. In these techniques, the graft is harvested from the palate; focusing on obtaining the inner connective tissue layer from the donor site while dismissing the external epithelial layer. This results in a double blood supply at the recipient site, not only from the periosteum nurturing the graft but also from the flap itself, which will cover the graft. Moreover, it eliminates the need for the donor site to heal by secondary intention, as the outer epithelial layer remains almost intact, thereby reducing post-operative discomfort.

An alternate technique for harvesting the connective tissue graft involves obtaining a free gingival graft and subsequently de-epithelializing it, leaving only the connective tissue layer [120,144]. This approach proves easier, particularly in patients with thinner tissue. However, the primary concern associated with this technique is the postoperative pain from the palatal donor area due to secondary intention healing. Additionally, a “mixed” graft, incorporating both epithelialized and de-epithelialized components, has also been used to treat gingival recessions [145]. Several variations of this technique have emerged in the literature over the years [146,147].

The tunneling technique has emerged as one of the leading mucogingival procedures for root coverage, gaining widespread popularity in recent years (Fig. 11). Initially inspired by Raetzke’s [142] method of employing a partial thickness pouch, termed an “envelope” flap, to accommodate a CTG for single tooth recessions, it saw significant advancement through the seminal work of *Allen 1994* [148]. Allen’s modifications extended its applicability to treating multiple adjacent recessions by including the papillae and securing the graft with sutures. The term “tunnel” was introduced by Zabalegui et al. 1999 [149], who further refined the technique. Notably, these techniques lacked a coronal advancement of the flap, resulting in partial exposure of the CTG. It was not until Azzi et al. 2002 [150] proposed a full-thickness flap modification, displacing all the gingival units coronally, thus ensuring complete coverage of the graft. Subsequently, numerous authors have continued to refine the tunneling technique to optimize root coverage and enhance esthetics while also focusing on minimizing tissue trauma, simplifying the procedure, reducing surgical time, and incorporating soft tissue substitutes [151–158].

Introducing microsurgery enhanced therapeutic outcomes during mucogingival therapy, improving root coverage, wound healing, and overall esthetic outcomes [159–161]. Another more recently introduced but increasingly popular technique is the VISTA technique, which includes a vestibular incision, which allows graft access in the flap and augments the coronal advancement with composite-retained sutures on the coronal surface [162].

The technique introduced by *Zucchelli and De Sanctis* [163] stands as one of the foremost approaches in flap management for root coverage.

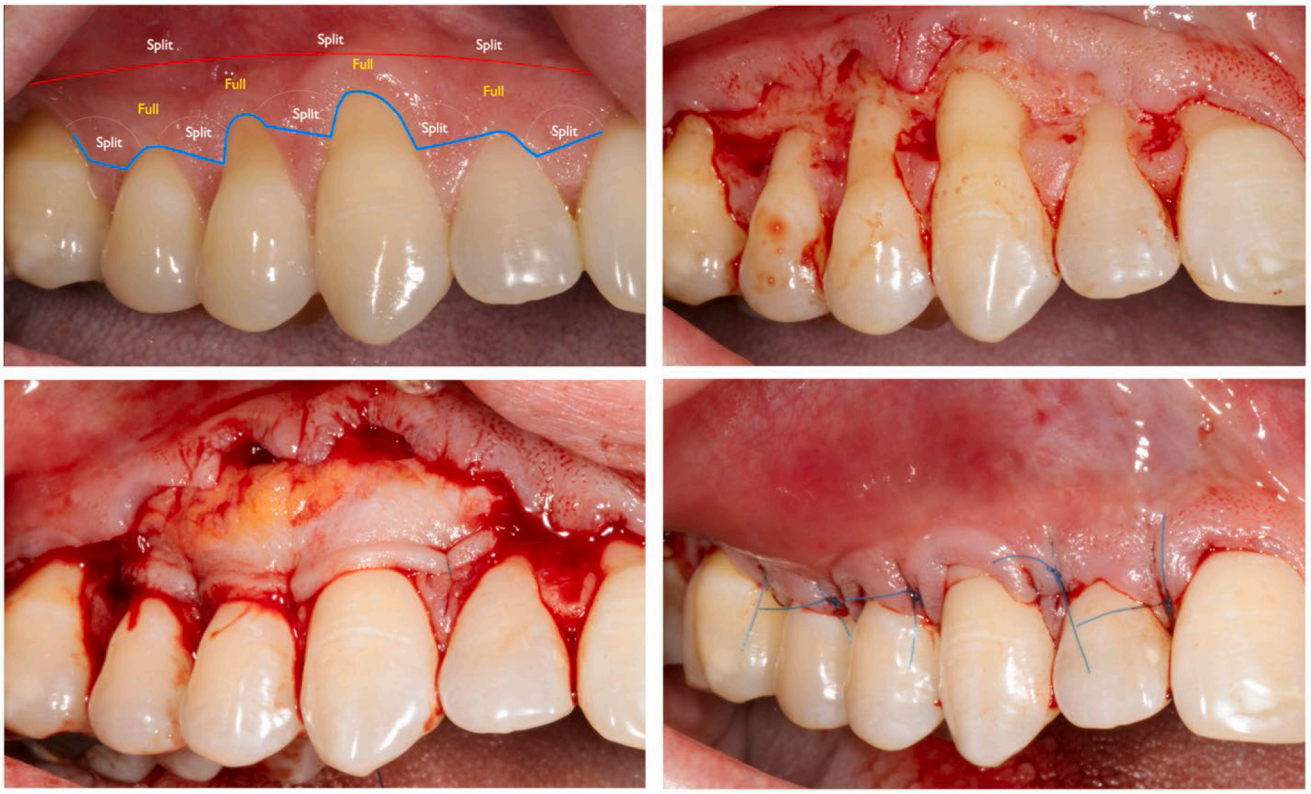

Fig 12. Subepithelial CTG using the *Zucchelli & De Sanctis 2000* [163] technique. (A) Pre-operative view showing the areas of "split-full-split" thickness flap preparations. (B) Recipient bed preparation showing extensive hidden recessions. (C) CTG harvested from the palate and adequately secured in the recipient bed. (D) Flap advancement covering the CTG.

Fig 13. Acellular dermal matrix graft using a tunnel technique and subpapillary-continuous sling suture. (A) Pre-operative view. (B) ADM showing the final position under the flap. (C) ADM was placed using a tunnel technique and subpapillary-continuous sling suture technique. (D) Post-operative result: 2 weeks (E) Post-operative result: 3 months. (F) Post-operative result: 18 months follow-up and full arch rehabilitation.

This surgical approach involves oblique sub-marginal incisions in the interdental areas, followed by intrasulcular incisions around the involved teeth. The flap is then elevated in a "split-full-split" manner, characterized by split-thickness in the coronal portion, full thickness in the central portion at the level of the tooth sulcus, and split-thickness apically. De-epithelialization of the interdental papillae is performed to establish a connective tissue bed (Fig. 12). Notably, this surgical technique exhibits several variations [164,165], with some focusing on modifications tailored for the treatment of multiple gingival recessions limited to the anterior teeth [166], while others incorporate diverse soft tissue graft materials to enhance outcomes [63,163–166].

The literature offers a wide array of surgical techniques for soft tissue augmentation, each designed with distinct objectives and varying levels of success. Efforts to standardize clinician's approaches have led to the

development of decision trees aimed at aligning treatment strategies with specific goals [117,167,168]. Nevertheless, the landscape remains diverse, reflecting the multifaceted nature of soft tissue augmentation procedures.

In this context, ADM emerges as a noteworthy tissue allograft alternative to the conventional connective tissue graft, often integrating elements of the aforementioned flap techniques (Fig. 13). However, the literature's consensus on its efficacy is mixed, with some studies favoring autografts (CTG) while others report comparable outcomes [117, 169–174]. Similarly, the use of xenogeneic collagen matrices has yielded controversial findings [175–178].

In summary, while allogenic and xenogenic substitutes offer viable alternatives to connective tissue grafts; the superiority of the latter persists in long-term results, maintaining its status as the gold standard in soft tissue augmentation procedures [179,180].

4. Conclusions

Gaining insight into the main etiological factors predisposing patients to develop mucogingival deficiencies is critical before determining the need for treatment. Soft tissue grafting surgical procedures constitute a staple in periodontal practice, and various techniques and alternatives are available to clinicians. Careful diagnosis, setting achievable expectations, establishing clear goals, and meticulous technique selection are essential for achieving optimal clinical outcomes.

Declaration of competing interest

The authors declare that they do not have any financial interests or personal relationships that could have appeared to influence the work reported in this article. The authors report no conflict of interest.

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