



SURGICAL TREATMENT OF GINGIVAL RECESSION WITH SOFT TISSUE GRAFT PROCEDURE

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ABSTRACT

Periodontal plastic surgery is part of mucogingival therapy. The aim of this surgical procedure is to prevent or correct anatomic, developmental, traumatic or disease-induced defects of the gingiva, alveolar mucosa or bone.

This definition includes various soft- and hard-tissue procedures aimed at gingival augmentation, root coverage, correction of mucosal defects at implants, crown lengthening, gingival preservation at ectopic tooth eruption, removal of aberrant frenum, prevention of ridge collapse associated with tooth extraction and augmentation of the edentulous ridge. This review focuses on gingival recession defects, their diagnosis and prognosis and the surgical procedures for root coverage. Etiology of gingival recession is multifactorial and include: anatomical, physiological and pathological factors. The treatment of gingival recession defects is indicated for esthetic reasons, to reduce root hypersensitivity and to create or augment keratinized tissue.

Gingival recession can be treated with various surgical procedures, and root coverage can be obtained irrespective of the surgical approach adopted.

Keywords: gingival recession, surgery, soft tissue graft

INTRODUCTION

Gingival recession is an apical shift of the gingival margin with exposure of the root surface to the oral cavity. Recession may exist in the presence of normal sulci and nondiseased interdental crestal bone levels, or it may occur as part of the pathogenesis of periodontal disease during which alveolar bone is lost. Etiological factors that may be associated with gingival recession are a pre-existing lack of alveolar buccal bone at the site- developmental (anatomical) or acquired (physiological or pathological). [1].

Gingival recession can be treated with various surgical procedures, and root coverage can be obtained irrespective of the surgical approach adopted. The most important prognostic factor for root coverage following surgery is the height of the interdental periodontal support (clinical attachment and alveolar bone levels). In the case of a periodontally healthy tooth, the papillae completely fill the interdental

spaces, and there is no clinical attachment loss or bone loss; periodontal probing and intraoral X-ray may be helpful to confirm the healthy condition. Gingival recessions have been classified by Miller into four classes, according to the prognosis of root coverage. [2]

The treatment of gingival recession and its sequelae is based on an assessment of the etiological factors and the degree of tissue involvement. The initial part of the management of the patient with gingival recession should be eliminating or correcting the etiological factors. The degree of gingival recession must be assessed and has to be monitored for signs of further progression. Surgical root coverage is indicated for esthetic reasons, to reduce root hypersensitivity and to create or augment keratinized tissue in a patient with good periodontal health. [2]

Indications for root coverage procedures

The treatment of gingival recession defects is indicated for esthetic reasons, to reduce root hypersensitivity and to create or augment keratinized tissue [3]. Indications for root coverage procedures are root abrasion/caries and the inconsistency of the gingival margin. [4, 6]

Esthetic reasons

The main indication for treatment of gingival recessions is patient demand. The excessive length of the tooth/teeth (i.e. those with the recession) may be evident when smiling or during phonation. Esthetic 'shortening' of the tooth can only be accomplished with root coverage for surgical procedures.

Root sensitivity

Sometimes the patient complains of hypersensitivity especially to cold at the level of teeth affected by the gingival recession. This is a cause of discomfort and/or pain and can make proper oral hygiene very difficult to perform. If there is no concomitant esthetic complaint related to the excessive tooth length, a less invasive (and patient-appreciated) treatment is the local application of chemical desensitizing agents. If this is not effective, a restorative treatment (composite fillings) may be performed. If and when dentine hypersensitivity is associated with a patient complaint about esthetics, treatment of gingival recession should be surgical or combined restorative-surgical (restorative-mucogingival approach). [2]

Keratinized tissue augmentation

The indication for treatment of gingival recession may also result from the site-specific patient difficulty/inability to maintain adequate plaque control because of the deep, narrow nature of the recession defect or the absence of keratinized tissue.

Root abrasion/caries

The indication for treatment of gingival recession may also derive from the concomitant presence of root demineralization/caries or deep abrasion defects that can cause hypersensitivity and/or may render the patient's plaque control difficult. Treatment of radicular caries/abrasion associated with gingival recession can be surgical or combined restorative-surgical, depending on the potential to cover with soft tissue, or not cover, the area affected by abrasion or caries (see the prognosis of root coverage) [4, 6].

Inconsistency of gingival margin

Inconsistency/disharmony of the gingival margin may be caused by the morphology of the gingival recession, even in the absence of dentin hypersensitivity, which may prevent the patient performing an effective toothbrushing technique. This is especially true when gingival recessions are isolated and deep, when they are very narrow with triangular-shape vertices (the so-called 'Stillman cleft') or when they extend beyond the mucogingival junction. The only feasible treatment is root coverage surgery. [6]

Root coverage procedures

The ultimate goal of a root coverage procedure is complete coverage of the recession defect with a good appearance related to the adjacent soft tissues and minimal probing depth following healing [2]

Surgical procedures used in the treatment of recession defects may basically be classified as follows [2].

Pedicle soft-tissue graft procedures:

- > Rotational flap procedures (laterally sliding flap, double papilla flap, oblique rotated flap);
- > Advanced flap procedures (coronally repositioned flap, semilunar coronally repositioned flap);
- > Regenerative procedures (with barrier membrane or application of enamel matrix proteins)

Free soft-tissue graft procedures:

- > Epithelialized graft;
- > Subepithelial connective tissue graft

The international literature has thoroughly documented that gingival recession can be successfully treated using several surgical procedures, irrespective of the technique utilized, provided that the biological conditions for accomplishing root coverage are satisfied (no loss in the height of interdental soft and hard tissue).

The selection of one surgical technique over another depends on several factors, some of which are related to the *defect (the size and number of the recession defects, the presence/absence, quantity/ quality of keratinized tissue apical and lateral to the defect, the width and height of the interdental soft tissue (papillae), the presence of frenum or muscle pull and the depth of the vestibulum)*, whereas others are related to the patient. The esthetic request and the need to minimize postoperative discomfort are the most important *patient-related factors* to be considered in the selection of

the root coverage surgical approach. Furthermore, the clinician must consider data from the literature in order to select the most predictable surgical approach, among those feasible in a given clinical situation. [2]

In a patient with esthetic requests, pedicle flap surgical techniques (coronally advanced or laterally moved flaps) are recommended if there is adequate keratinized tissue apical or lateral to the recession defect [7]. In these surgical approaches the soft tissue utilized to cover root exposure is similar to that originally present at the buccal aspect of the tooth with the recession defect, and thus the esthetic result is satisfactory. Furthermore, the postoperative discomfort is minimal as second surgical sites (palate) far from the tooth with the recession defect are not involved.

Conversely, when the keratinized tissue apical or lateral to the gingival defect is not adequate, free graft procedures have to be performed. The use of free gingival grafts to treat recession defects in patients with esthetic requests is not recommended because of the poor esthetic outcome and the low root coverage predictability. The use of a pedicle flap to cover the graft (i.e. the bilaminar technique) improves the root coverage predictability (by providing an additional blood supply to the graft) and the esthetic result (through hiding the white-scar appearance of the graft and masking the irregular outline of the mucogingival junction that frequently occurs after a free graft procedure) [8]. This paper will focus in particular on those surgical procedures that have been reported to be more predictable in achieving root coverage. From a clinical standpoint, it can be useful to classify them in root coverage surgical procedures for single and for multiple recession-type defects.

Pedicle soft tissue graft procedure for single recessions

Coronally advanced flap

The coronally advanced flap procedure is a very common approach for root coverage. This procedure is based on the coronal shift of the soft tissues on the exposed root surface. It is the technique of choice for the treatment of *isolated gingival recession*. It is technically simple, well tolerated by the patient [because the surgical area is limited and does not require removal of tissue far from the tooth with the gingival recession (palate)] and provides optimal results from an esthetic point of view. The conditions required to perform the coronally advanced flap are the presence of keratinized tissue, apical to the root exposure, of an adequate height (1 mm for shallow recessions and 2 mm for recessions e"5 mm) and thickness. The technique was initially described by Norberg and subsequently reported by Allen & Miller. It was modified later using a trapezoidal flap design and a split-full-split-thickness flap elevation approach. According to some authors this technique resulted in a very high mean percentage (99%) and complete (88%) root coverage at the first year; and these outcomes were similar [9], or even higher [10], than those reported in the literature for other root coverage procedures. The 3-year outcomes showed only a slight decrease compared with those at 1 year: 97% of root coverage and 85% of complete root coverage. [11] A recent systematic review concluded that the coronally advanced flap procedure

is a safe and predictable root coverage surgical procedure for the treatment of single type gingival recessions. [12] *The modified coronally advanced flap technique* presented some clinical and biologic advantages over the split–full–split-thickness flap elevation. [11] The split-thickness elevation at the level of the wide (3 mm) surgical papilla provided anchorage and blood supply to the interproximal areas mesial and distal to the root exposure. Furthermore, the partial thickness of the surgical papillae facilitated the nutritional exchanges between them and the underlying de-epithelialized anatomical papillae and improved the blending (in terms of color and thickness) of the surgically treated area with respect to the adjacent soft tissues. The full-thickness elevation of the soft tissue apical to the root exposure conferred more thickness and some periosteum, and thus better opportunity to achieve root coverage to that portion of the flap residing over the exposed avascular root surface. The more apical split-thickness flap elevation facilitated the coronal displacement of the flap. Although the technique included vertical releasing incisions, these did not result in unesthetic scars. These incisions were beveled in such a way that the bone and periosteal tissues were not included in the superficial cut and thus did not participate in the healing process. [11, 12] Another important modification of the present surgical technique, with respect to the previously proposed techniques, was that the coronal advancement of the flap was not obtained by periosteal incisions, but rather by cutting the muscle insertions included in the thickness of the flap. A ‘deep’ incision (with the blade parallel to the bone) detached the lip muscle from the periosteum and permitted the performance of a ‘superficial’ incision (with the blade parallel to the lining mucosa) that allowed for the coronal advancement of the flap. These incisions minimized lip tension on the flap and permitted passive displacement of the flap soft-tissue margin in a coronal position. A further technical aspect that was considered critical for the success of the modified coronally advanced flap procedure related to the coronal sling suture. The anchorage to the palatal cingulum permits precise adaptation of the keratinized tissue of the flap to the convexity of the crown of the treated tooth. This minimizes exposure of the coagulum, which forms between the soft tissue and the root exposure, to the detrimental microbiological and traumatic agents of the oral environment. The increased stability of the coagulum may play a role in preventing early flap dehiscence and thus favor root coverage. The need for a tight coronal adaptation of the keratinized tissue of the flaps at the time of suturing represented another indication, together with the esthetic indication, for a composite reconstruction, before surgery, of the convexity of the tooth crown interrupted by the presence of noncarious cervical lesions. [11, 12, 13]

A large increase in keratinized tissue height was demonstrated after coronally advanced flap surgery in the study by De Sanctis & Zucchelli [11] that 3 years after the surgery, the mean increase of keratinized tissue was 1.78 mm, and this increase was greater in sites with deeper recession and a lower amount of residual keratinized tissue at baseline. Very similar results were obtained in a previous study evaluating the 5-year outcomes of the coronally positioned flap for multiple

gingival recessions [12]. Some hypotheses were made in an attempt to explain the increase of keratinized tissue after coronally advanced flap surgery: the tendency of the mucogingival line, coronally displaced during the surgery, to regain its original, ‘genetically determined’ position or the capability of the connective tissue, deriving from the periodontal ligament, to participate in the healing processes taking place at the dento-gingival interface. The observation that the increase in keratinized tissue height was greater when, before surgery, there was a greater recession depth, and a narrower residual band of attached gingiva apical to the defects seem to support the hypothesis of the tendency of the mucogingival junction to regain its genetically determined position. In fact, these were the clinical situations in which a greater coronal displacement of the mucogingival line was performed during the surgery. The repositioning of the mucogingival line could also explain the great variability among patients (and studies) in the increase of keratinized tissue height after coronally advanced flap procedures. One can speculate that patient biotype might influence the increase in keratinized tissue after surgery and patients with a more apical position of the mucogingival line will experience a greater increase of keratinized tissue height after coronally advanced flap surgery relative to patients with a more coronal location of the mucogingival junction. Randomized comparative clinical trials of different patient biotypes are advocated to test this hypothesis. Pini Prato et al. [13] evaluated, in a long-term 14-year randomized split-mouth study, the outcomes of two different methods of root-surface modifications (root-surface polishing compared with root planing) used in combination with a coronally advanced flap performed for the treatment of single type gingival recessions. The authors observed that, during the 14-year follow-up period, an apical shift of the gingival margin occurred in 39% of the patients treated in both groups, showing a progressive worsening of the gingival recessions with time. The observed relapse of the soft-tissue defects could be ascribed to a resumption of traumatic toothbrushing habits in patients with high levels of oral hygiene, even if they were included in a stringent maintenance protocol with recall every 4–6 months. Regarding the keratinized tissue width, the results of Pini Prato et al. [13] showed its tendency to decrease over time. The same authors evaluated the outcomes of coronally advanced flap for the treatment of single gingival recessions in another long-term 8-year case series study. They reported that an apical shift of the gingival margin occurred in 53% of the cases and that this was associated with a reduction of keratinized tissue; furthermore, the baseline amount of keratinized tissue was indicated as a prognostic factor for recession reduction: the greater the width of keratinized tissue, the greater the reduction of the recession. [13]

The main contraindications for performing the coronally advanced flap as a root coverage procedure are the absence of keratinized tissue apical to the recession defect, the presence of a gingival cleft (‘Stillman’ cleft) extending into the alveolar mucosa, high frenulum pull at the soft-tissue margin, deep root-structure loss, buccally dislocated root and a very shallow vestibulum depth.

Laterally repositioned flap

The laterally repositioned flap is advocated when the local anatomic conditions may render, and the coronally advanced flap is contraindicated. It is not the technique of choice in patients with high esthetic demands (as scar tissue forms in the secondary intention healing at the donor site) but it is well accepted by the patient because it does not involve the withdrawal of tissue from a distant area (the palate) and has an excellent postoperative healing course. In the literature, most reports on the laterally repositioned flap technique are quite dated. Various authors suggested several modifications to the original laterally sliding flap described by Grupe & Warren [7] in 1956 in order to reduce the risk of gingival recession at the donor site. Staffileno, proposed the use of a partial-thickness flap, instead of a full-thickness flap, to cover the root exposure. Grupe in 1966 suggested performing a submarginal incision at the donor site in order to preserve the marginal integrity of the tooth adjacent to the recession defect. Ruben et al. in 1976 introduced a mixed-thickness flap that consisted of a full-thickness flap, performed close to the recession defect for covering the root exposure, and a split-thickness flap created laterally to the full-thickness flap, for covering the bone exposure occurring at the donor site of the full-thickness flap.[7,14] The most recent publication, before 2004, on the laterally repositioned flap as a root coverage surgical technique, dates back to 1988. [7] The reason for the lack of more recent interest is related to the *low predictability and efficacy of the laterally repositioned flap* as a root coverage surgical procedure. In the literature, the reported mean percentage of root coverage ranges between 34% and 82% [14]. Complete root coverage data are lacking, with only one study [15] reporting data ranging between 40% and 50%. All techniques reported in the literature consisted of the lateral shift of the pedicle flap only. More recently, Zucchelli et al.[9] suggested a modification of the surgical approach, which added coronal advancement to the lateral movement of the pedicle flap ('laterally moved coronally advanced flap'). In this study, precise measurements of the keratinized tissue lateral to the root exposure were requested: the mesial-distal dimension was 6 mm more than the width of the recession measured at the level of the cemento-enamel junction, whilst the apical-coronal dimension was 3 mm more than the facial probing pocket depth of the adjacent donor tooth. The main surgical modifications consisted of the different thickness during flap elevation; split at the level of the surgical papillae, full in that portion of the flap covering the avascular root surface and split again apical to the mucogingival line; the deep and superficial cuts of the muscle insertions to permit coronal advancement of the flap; the de-epithelialization of the anatomical papillae to provide coronal anchorage to the surgical papillae of the flap; and the coronal sling suture anchored to the palatal cingulum of the treated tooth. This technique resulted in a very high mean percentage of root coverage (96%), and complete root coverage was accomplished in the great majority (80%) of patients treated. A recent 24-month study assessed the clinical results obtained with full-thickness laterally positioned flap and citric acid root conditioning for the treatment of localized gingival recession; the mean percentage of root coverage was 94%, and

complete root coverage was 63%. The laterally moved coronally advanced flap is mainly indicated for the treatment of deep single type gingival recession defects affecting a lower incisor or the mesial root of the upper first molar. In the latter case, the presence of very deep bone dehiscence must be expected. Graft techniques would require the withdrawal of a very large (in apical-coronal dimension and thickness) amount of tissue from the palate, with an unpleasant postoperative course for patients. [9]

Regenerative procedures

Barrier membranes

Guided tissue regeneration with resorbable and non-resorbable membranes has been used for the treatment of gingival recessions. This procedure has been shown to offer a predictable modality for root coverage (especially in deep recessions, resulting in the regeneration of new connective tissue attachment and bone. The root coverage obtained by polytetraethylene membranes or bioresorbable membranes ranges from 54% to 87% (with a mean of 74%) and the use of the membrane technique also resulted in several problems such as membrane exposure and contamination, technical difficulties in placing the barrier and possible damage of the newly formed tissue as a result of membrane removal or absorption. [10] Furthermore, recent literature shows that the use of a barrier membrane, in conjunction with a coronally advanced flap, does not improve the result of the coronally advanced flap alone in terms of complete root coverage and recession reduction. At present, the use of a barrier membrane for root coverage procedures appears to be inadvisable, especially considering the high incidence of complications (i.e. membrane exposure) [16].

Enamel matrix derivative

Enamel matrix derivative, in combination with a coronally advanced flap, was introduced to treat gingival recession with the double objective of enhancing root coverage results and inducing periodontal regeneration. Recent literature reviews showed that enamel matrix derivative, in conjunction with a coronally advanced flap, improved the percentage of complete root coverage, increased keratinized tissue height and provided a better reduction of recession. Histological studies are contradictory, reporting either predominant attachment consisting of collagen fibers running parallel to the root surface without new cementum or Sharpey's fibers and with new bone and new cementum forming only in the most apical portion of root surface, or periodontal regeneration with connective tissue attachment, new bone and new cementum [17]. The true clinical rationale to choose this approach with respect to the coronally advanced flap alone or other techniques is unclear; thus, routine use of enamel matrix derivative associated with a coronally advanced flap is not recommended. One may speculate that the application of enamel matrix derivative during mucogingival surgery may be recommended in situations in which a wider extension of new attachment formation between the soft tissue and the root surface could be of clinical relevance. This may be a result of the size of root exposure (a very wide and deep recession defect), or the tooth position (buccally dislocated root) or a concomitant bucco-lingual attachment and bone loss (see histological healing after root coverage sur-

gery). Clinical and histological studies are advocated to confirm such a hypothesis. [17]

Free soft-graft procedures

Epithelialized gingival graft

The free gingival graft is the most widely used surgical technique for increasing the width of attached gingiva. Several authors observed a low degree of predictability of favorable results with this technique in the coverage of exposed root surfaces. In fact, a portion of the graft placed on the denuded root surface does not receive adequate blood supply, with consequent partial necrosis of the grafted tissue. The literature on free gingival grafts is contradictory and reports the percentages of root coverage ranging from 11% to 100% [18]. This variation may be attributed to differences in the severity of the gingival lesion and in surgical techniques. Nowadays, free autogenous gingival grafts are the last resort when the main goal is root coverage or particularly to meet the esthetic demands of patients. An unfavorable esthetic outcome is related to incomplete root coverage, the white-scar appearance of the grafted tissue that contrasts with the adjacent soft tissues and the malalignment of the mucogingival line. Free gingival grafts can still be used when the main goal of the surgical procedure is to augment keratinized tissue height (especially in mandibular incisors without attached gingiva and with aberrant frenuli), the thickness of gingival tissue and the vestibulum depth. When used for root coverage purposes, the graft should be sutured coronally to the cemento-enamel junction (to compensate for soft-tissue shrinkage); its thickness should be >1 mm (to increase root coverage predictability); and it should be adapted to the convexity of the crown (to minimize coagulum exposure and destabilization). The free gingival graft is contraindicated in patients with esthetic demands, in deep and wide recession defects and in the presence of deep facial probing pockets associated with gingival recession. Free autogenous gingival grafts can be used as the first surgical procedure in the two-stage technique described by Bernimoulin et al. in 1975. [12] This consists of the first stage of surgery, in which a free gingival graft is performed to increase the keratinized tissue height apical to the gingival recession, and a second stage in which the grafted tissue is coronally advanced to cover the exposed root surface. A mean percentage of root coverage ranging from 65% to 72% was reported for the two-stage technique. This procedure is not well accepted by the patient because of the two surgical stages. However, there could be a combination of unfavorable conditions at the tooth with the gingival recession that renders this technique as indispensable: the lack of keratinized tissue apical and/or lateral to the root exposure; gingival cleft extending beyond the mucogingival line; and the presence of a shallow vestibulum depth. A recent case report introduced a modified two-stage surgical procedure aiming to improve the esthetic outcome and reduce the patient's morbidity. The main modification of the first stage of surgery consisted of harvesting a free gingival graft of the same height as the keratinized width of the adjacent teeth and suturing it on the periosteum apical to the bone dehiscence. During the second stage of surgery, the coronal advancement of the grafted tissue led to root coverage and realignment of the mucogingival line. [18] Zucchelli and

De Sanctis [12] showed that by minimizing the apical coronal dimension of the free graft and standardizing the surgical techniques, successful results (in terms of root coverage, increase in keratinized tissue and achieving a color similar to that of the adjacent soft tissues) could be obtained in the treatment of gingival recessions characterized by local conditions, which otherwise preclude, or render unpredictable, the use of one-step root coverage surgical techniques. Randomized controlled studies are advocated to test the efficacy and predictability of the two-stage root coverage surgical technique. [12]

Subepithelial connective tissue graft (bilaminar technique)

The recent literature indicates the bilaminar techniques as the most predictable root coverage of surgical procedures [19]. The biological rationale for these techniques is to provide the graft with an increased blood supply from the covering flap. This will increase the survival of the graft above the avascular root surface and improve the esthetic outcome by hiding, partially or completely, the white-scar appearance of the grafted tissue. During the last two decades, clinicians have introduced several modifications to the original bilaminar technique described resulting in more predictable outcomes, in terms of root coverage, and greater esthetic satisfaction for patients. These modifications were related to the type of graft (partially or completely de-epithelialized) harvested from the palate and to the design (envelope type or with a vertical releasing incision) of the covering flap. Some authors used an envelope flap or a repositioned flap to partially cover epithelial, connective tissue grafts. Others utilized coronally advanced flaps, with or without vertical releasing incisions, or a laterally moved papillae flap to cover connective tissue grafts. In all surgical approaches reported, the size of the graft exceeded that of the bone dehiscence, and it was positioned (and sutured) at the level of, or mainly coronal to, the cemento-enamel junction. [19, 20] Although root coverage became increasingly more predictable, the esthetic appearance of the surgically treated area was often different from that of the adjacent soft tissues. This was caused by the chromatic difference between the uncovered epithelialized portion of the graft and the adjacent soft tissues the dischromy associated with partial exposure of the connective tissue graft as a result of early dehiscence of the covering flap, or the difference in thickness between the grafted area and adjacent soft tissues. [19] More recently, in a comparative study by Zucchelli et al. [20], a further modified approach was proposed to improve the esthetic outcome of the bilaminar root coverage procedure. The main surgical modifications related to the size and positioning of the connective tissue graft: the apico-coronal dimension of the graft was equal to the depth of the bone dehiscence (measured from the cemento-enamel junction to the most apical extension of the buccal bone crest) minus the preoperative height of keratinized tissue apical to the recession defect. The thickness of the graft was <1 mm. The connective tissue graft was positioned apical to the cemento-enamel junction at a distance equal to the height of keratinized tissue originally present apically to the root exposure. This approach was able to improve patient esthetic satisfaction and postoperative course (as a result of the lower

dimension of the withdrawal), whereas no difference in terms of root coverage outcomes (mean percentage and percentage of complete root coverage) were reported with respect to a more traditional approach. The successful root coverage outcome of this approach could be explained by the capacity of connective tissue grafts to reduce the apical relapse of the coronally positioned gingival margin during the healing phase of the coronally advanced flap procedure. The main indications for the use of a bilaminar root coverage surgical technique are gingival recession in patients with a high esthetic demand in whom the coronally advanced flap is contraindicated as a result of the absence/inadequacy of keratinized tissue apical to the root exposure; gingival recession associated with deep root abrasion, root prominence and root pigmentation (a dark/orange root surface); and gingival recession associated with prosthetic crowns or implants. Contradictions for the bilaminar techniques are those anatomic situations limiting the possibility to perform pedicle covering flaps (marginal frenuli, high muscle pull, gingival cleft extending in alveolar mucosa and a very shallow vestibulum depth), especially when these unfavorable conditions, in fact, occur more frequently in the lower incisions zone. [19,20]

Connective tissue graft-harvesting procedures

Different connective tissue graft-harvesting procedures, with the purpose of achieving primary intention palatal wound healing, have been described in the literature: the most common are the trap-door procedures and the envelope techniques with single or double incisions [21]. These procedures have the following common characteristics: a primary split-thickness access flap elevation; the withdrawal of connective tissue graft; and complete closure of the palatal wound with the access flap. The primary objective of these techniques is to reduce patient morbidity by obtaining primary closure of the wound and primary intention healing; however, they need an adequate thickness of the palatal fibromucosa to avoid desquamation of the undermined superficial flap as a result of compromised vascularization. The free gingival graft surgical wound heals by secondary intention within 2–4 weeks and has been consistently associated with greater discomfort for the patient as a result of postoperative pain and/or bleeding. However, this technique is easy to perform and can be utilized even in the presence of a thin palatal fibromucosa. [21]

The evidence in the literature evaluating differences in patient outcomes and morbidity following use of the connective tissue graft and free gingival graft for root coverage procedures is minimal. A few prospective comparative studies reported poorer patient outcomes, specifically a greater incidence of postoperative pain, for free gingival grafts compared with connective tissue graft procedures. Recently, a clinical randomized controlled study was performed to compare the postoperative morbidity and root coverage outcomes in patients treated with trap-door connective tissue (control group) and epithelialized (test group) graft-harvesting techniques for the treatment of gingival recession using the bilaminar procedure. [22] In the test group, the connective tissue graft was obtained after de-epithelialization of the epithelialized graft with a scalpel blade. [22] No statistically

significant differences in painkiller consumption, postoperative discomfort and bleeding (recorded using the visual analog scale) were found between the two groups. By contrast, necrosis of the primary flap in the control patients resulted in a six-fold increase in the intake of anti-inflammatory drugs. The reasons for the lack of differences between the two patient groups are open to speculation; however, a possible explanation may be found in the surgical techniques and, in particular, in the reduced dimensions of the graft or in the protection of the wound area with equine-derived collagen in the test group. At present, study data demonstrate that the height (the apical-coronal dimension) and depth of the harvesting graft, but not the type (primary compared with secondary) of palatal wound healing influence postoperative analgesic consumption. The results of the study also indicate that both types of connective tissue graft can be successfully used under a coronally advanced flap to cover gingival recession, with no statistically significant difference in root coverage outcomes between the grafts. One year post-treatment, 92% of the control of gingival defects and 97% of the test gingival recessions were covered with the soft tissue. Furthermore, complete root coverage was achieved in 70% of the controls and in 85% of the test subjects. The only statistically significant difference in the clinical outcomes between the two treatment groups was the greater increase in gingival thickness in the patients treated with the de-epithelialized graft.[22] Any attempt to explain this difference is speculative in nature, but it may be related to the better quality (greater stability and less shrinkage) of the more superficial connective tissue resulting from the de-epithelialization of a free gingival graft with respect to the deeper connective tissue harvested using the trap-door approach [22].

Surgical procedures for multiple recessions

Gingival recession is rarely localized to a single tooth, and no reports are available on the prevalence of single recession defects compared with multiple recession defects; nevertheless, clinical experience indicates a greater incidence of multiple gingival recessions. In the presence of multiple defects, the attempt to reduce the number of surgeries and intraoral surgical sites, together with the need to satisfy the patient's esthetic demands, must always be taken into consideration. Thus, when multiple recessions affect adjacent teeth they should be treated at the same time and, if possible, the removal of soft tissue from distant areas of the mouth (palate) should be minimized to reduce patient discomfort [23].

To date, extensive evidence reports positive outcomes following the use of root coverage procedures in the treatment of localized gingival recessions whilst few studies are currently available reporting the outcomes for the treatment of multiple gingival recessions. The coronally advanced flap for multiple recessions was introduced by Zucchelli & De Sanctis [12] as a novel approach to treat more than two adjacent teeth with gingival recession. This technique comprises an envelope type of flap (with no vertical releasing incisions); an innovative flap design that anticipates the rotational movement of the surgical papillae during the coronal advancement of the flap; a split (at the level of the surgical papillae) – full (at the soft tissue apical to the root exposure) – split

(apical to bone exposure) approach during flap elevation; a double incision (one to dissect muscle insertions from the periosteum and the other to cut muscle from the inner connective tissue lining the mucosa of the flap) to permit coronal advancement of the flap; the de-epithelization of the anatomic papillae; and a various number of sling sutures anchored to the palatal cingulum of the treated teeth. This case series reported 97.1 5.1% mean root coverage and 88.6 20.3% complete root coverage. A long-term study (5years) conducted by the same authors reported stability of the successful outcomes obtained at 1 year of evaluation: 94% of the root surfaces initially exposed by the gingival recession were still covered with soft tissue, and 85% of the treated recession defects showed complete coverage. [12]

A recent systematic review evaluated the results obtained with different root-coverage procedures in the treatment of multiple recession-type defects- coronally advanced flap coronally advanced flap plus subepithelial connective tissue and subepithelial connective flap with a modified coronally advanced flap [24]. A mean percentage of root coverage of 96% was reported, with 73% of complete root coverage. The authors concluded that all the periodontal plastic surgery procedures evaluated (i.e. a coronally advanced flap, either alone or in combination with a subepithelial connective tissue graft) led to improvements in recession depth, clinical attachment level and width of keratinized tissue; further multicenter studies may be required to increase the number of patients and to achieve adequate statistical power. [24]

A recent randomized clinical trial comparing coronally advanced flap, with or without vertical releasing incisions, for the treatment of multiple recession, did not report differences in terms of the mean percentage of root coverage between both approaches. However, the envelope type of coronally advanced flap was associated with an increased probability of achieving complete root coverage and with a greater increase of buccal keratinized tissue height. Patient satisfaction with esthetics (overall satisfaction, color match and amount of root coverage) was very high for both treatments, with no significant difference observed between them; better results, in terms of postoperative healing and esthetic evaluation, as judged by an independent expert periodontist, were obtained for patients treated with the envelope type of coronally advanced flap. Keloids, which may form along the vertical releasing incisions, were responsible for the worst esthetic evaluation made by the expert periodontist. [24]

The coronally advanced flap for multiple gingival recessions should not be considered only as a root coverage surgical procedure but also as a covering flap for connective tissue grafts (subepithelial connective tissue graft) should the keratinized band of tissue apical to the root exposure for root coverage be absent or inadequate. This inadequacy may be a result of the small height and/or thickness of the keratinized tissue itself or the presence of deep root abrasion or root prominence. Very little data are available on the effectiveness of subepithelial connective tissue grafts in the treatment of multiple recessions, and only two long-term studies have been published [25]. This trial compared the clinical outcomes of coronally advanced flap alone with those of coronally advanced flap plus connective tissue graft in the

treatment of multiple gingival recessions with 5 years of follow-up. Six months after surgery, no statistically significant difference between coronally advanced flaps plus connective tissue grafts and coronally advanced flaps alone was reported in terms of recession reduction and complete root coverage. A different trend was noted over time at the 6-month and 5-year follow-up time points. A slight coronal shift of the gingival margin occurred in the coronally advanced flap plus connective tissue graft, whilst a slight apical shrinkage of the margin was observed in the coronally advanced flap group. The progressive coronal improvement of the gingival margin level and the increased percentage of sites with complete root coverage observed at 5 years in the sites treated with coronally advanced flap plus connective tissue graft were explained with the 'creeping attachment' effect over time [26]. According to the authors, this effect was facilitated by the thick gingival tissue obtained after healing of the connective tissue graft [26]. Conversely, the apical shift of the gingival margin of the coronally advanced flap-treated sites at 5 years was ascribed to the lower thickness/amount of keratinized tissue achieved leading to possible apical relapse of the gingival margin during the maintenance phase. These data underline, to an even greater extent, the importance of renewing (refreshing) patient motivation for plaque control and an atraumatic tooth-brushing technique in the first year(s) post surgery. Data of the study carried out by Pini Prato et al. [26] could be interpreted as showing that the adjunct use of connective tissue does not really improve the surgical outcomes (until 6 months) compared with the coronally advanced flap procedure alone, but facilitates long-term patient maintenance. A recent randomized controlled trial compared short-term (6 months and 1 year) and long-term (5 years) clinical and esthetic outcomes of the coronally advanced flap, with and without connective tissue grafts, in the treatment of multiple gingival recessions. The authors showed that, in patients with high standards of oral hygiene and undergoing a very strict regimen of postsurgical control visits, both techniques were effective in reducing recession depth and achieving complete root coverage at 6 months and 1 year, with no statistically significant differences between these time points. Better results, in terms of postoperative course and color-match evaluation made by an independent expert periodontist, were obtained in patients treated with the coronally advanced flap procedure. Conversely, the coronally advanced flap plus connective tissue graft procedure was associated with an increased probability of obtaining complete root coverage at 5 years. Further investigations are advocated. [26]

Tunnel technique

The tunnel procedure for root coverage was introduced in 1994 and termed the suprapariosteal envelope technique. The unique characteristic of this procedure is that the interdental papillae are left intact. A connective tissue graft is placed in the tunnel, and it does not need to be completely covered as long as the dimension of the graft is sufficient to ensure graft survival. An advantage of not covering the graft completely is that additional keratinized tissue is gained, whereas a disadvantage is that the exposed tissue might not be an exact color match. [6,27]. Conversely, the absence of vertical incisions has a tendency to produce better esthetics.

Probably the main advantage of the technique is the minimally invasive nature of the surgery, which results in negligible postoperative discomfort at the recipient site. Recently, the tunnel technique was modified to include coronal positioning of the marginal tissue, which allows complete coverage of the graft (E. P. Allen, Center for Advanced Dental Education, Dallas, Texas; course manual). This was accomplished by dissecting more deeply to free up the facial tissue and by lifting the papillae off the interproximal septum from the facial and lingual aspects. These two features allow greater coronal mobilization of the tissue margin. Successful execution of the technique requires almost a microsurgical approach, using smaller, specially designed instruments, small sutures and a unique suturing technique. Aroca et al. [27] tested, in a controlled randomized split-mouth study, the efficacy of a modified tunnel plus connective tissue graft technique in the treatment of multiple Class III gingival recessions. The data showed predictable results at 1 year [27]. Recently in a split-mouth randomized controlled trial, showed the findings of treatment of Miller Class I and II multiple adjacent gingival recessions with a modified coronally advanced tunnel technique in conjunction with a connective tissue graft. At 12 months this technique resulted in statistically significant improvements in complete root coverage (85%), mean root coverage (90.18%) and mean keratinized tissue width (2.70.8 mm) compared with baseline ($P < 0.05$). [27]

Allograft

The subepithelial connective tissue graft is a predictable and versatile technique in which a bilaminar vascular environment is created to nourish the graft. However, harvesting the palatal area increases postoperative morbidity and is time-consuming. The need for a second surgical procedure to harvest donor tissue is a disadvantage of the connective tissue graft procedure because only a limited amount of donor tissue is available for multiple recession defects. Thus, there has been a desire to find a substitute for the autogenous donor tissue. As a response, acellular dermal matrix graft has been used as a substitute for connective tissue grafts in root coverage procedures. The acellular dermal matrix graft is a dermal allograft processed to extract cell components and the epidermis, whilst maintaining the collagenous scaffolding. The remaining dermal layer is washed in detergent solutions to inactivate viruses and to reduce rejection and then is cryoprotected and rapidly freeze-dried in a proprietary process to preserve its biochemical and structural integrity. The allograft acts as a scaffold for the vascular endothelial cells and fibroblasts to repopulate the connective tissue matrix and encourage the epithelial cells to migrate from the adjacent tissue margins. The healing process observed in the allograft is similar to that seen in autogenous grafts. Similar root coverage outcomes have been reported in several studies that compared coronally advanced flaps plus acellular dermal matrix grafts with coronally advanced flaps plus connective tissue grafts. [28]

Recent systematic reviews did not show a statistically significant difference between the coronally advanced flap plus the acellular dermal matrix graft compared with the coronally advanced flap alone in terms of complete root coverage, recession reduction and keratinized tissue gain, sug-

gesting no additional benefit with the use of the acellular dermal matrix graft.[28] The comparison between coronally advanced flap plus acellular dermal matrix graft and coronally advanced flap plus connective tissue graft showed no statistically significant differences for complete root coverage and recession reduction, even though a tendency favoring connective tissue grafts was observed for both variables. A statistically significant difference in gain of keratinized tissue was detected with use of the connective tissue graft. Furthermore, a meta-analysis of two studies showed large heterogeneity in recession reduction for both comparisons (coronally advanced flap plus acellular dermal matrix graft vs coronally advanced flap alone), thus indicating the possible influence of patient-related factors, operator skill and severity of recession on the clinical outcomes. The coronally advanced flap plus acellular dermal matrix graft gave better overall esthetic outcomes, as reported by both clinicians and patients when compared blind with the coronally advanced flap plus connective tissue graft, even though it showed less complete root coverage. This finding may be related to different color matches with adjacent tissues for the acellular dermal matrix graft and connective tissue graft, or poorer healing for the connective tissue graft, in which size exceeds the bone dehiscence [20]. The data from the literature on the use of acellular dermal matrix grafts for root coverage is not conclusive, and its use may be associated with ethical concerns and risk of disease transmission.

Recently, a new collagen matrix of porcine origin (Mucografts Prototype) has been developed. Its intended mechanism of action is through acting as a three-dimensional scaffold that allows the ingrowth and repopulation of fibroblasts, blood vessels and epithelium from surrounding tissues, eventually being transformed into keratinized tissue. Only one clinical trial investigating the use of a collagen matrix is available in the literature. [29] In this trial, the authors tested the efficacy of Mucograft to build up a clinically sufficient width of newly formed keratinized tissue and assessed the esthetic outcomes and postoperative morbidity in comparison with the connective tissue grafts technique. The collagen matrix, when used as a soft-tissue substitute aiming to increase the width of keratinized tissue or mucosa, appears to be as effective and predictable as the connective tissue graft. [29]

McGuire & Scheyer proposed a study to test whether the xenogeneic collagen matrix could be useful for covering recession defects compared with the gold-standard coronally advanced flap plus connective tissue graft. (30)The single-masked, randomized-controlled split-mouth trial showed an average of 84% root coverage at 6 months and 89% at 1 year with collagen matrix plus coronally advanced flap; better results were achieved with coronally advanced flap plus connective tissue graft: 97% of root coverage at 6 months and 99% at 1 year. The authors underlined that the measures, evaluated statistically, were different but balanced with subject-reported outcomes (subjects' assessments of pain/discomfort and esthetics), and that collagen matrix plus coronally advanced flap presented an intriguing comparison with the traditional connective tissue graft gold standard. A recent randomized controlled trial evaluated the use of a porcine

collagen matrix plus coronally advanced flap as an alternative to coronally advanced flap plus connective tissue graft for the treatment of gingival recessions. At 12 months, porcine collagen matrix plus coronally advanced flap resulted in a mean root coverage of 94% compared with a mean root coverage of 97% for coronally advanced flap plus connective tissue graft. [30] From a statistical point of view, these measures are different but, according to the authors, the outcomes achieved by the porcine collagen matrix plus coronally advanced flap procedure were clinically comparable with those of the coronally advanced flap plus connective tissue graft group and similar to those expected from the coronally advanced flap plus connective tissue graft, as stated in previous literature reviews. A recent single-blinded, randomized, controlled, split-mouth multi-center trial evaluated the clinical outcomes of the use of a xenogeneic collagen matrix (test group) plus the coronally advanced flap or coronally advanced flap alone in the treatment of localized recession defects. [30] At 6 months, root coverage (primary outcome) was 76% for test defects and 73% for control defects ($P = 0.169$), with 36% of test defects and 31% of control defects exhibiting complete root coverage. The increase in the mean width of keratinized tissue was higher in test defects (from 1.97 to 2.90 mm) than in control defects (from 2.00 to 2.57 mm) ($P = 0.036$). [30]

Test sites had more gain in gingival thickness (0.59 mm) than did control sites (0.34 mm) ($P = 0.003$). Larger (e^3 mm) recessions ($n = 35$ patients) treated with collagen matrix showed higher root coverage (72% vs 66%, $P = 0.043$), as well as more gain in keratinized tissue and gingival thickness. The authors (30) concluded that coronally advanced flap plus collagen matrix was not superior with regard to root coverage, but enhanced gingival thickness and width of keratinized tissue when compared with coronally advanced flap alone. For the coverage of larger defects, coronally advanced flap plus collagen matrix was more effective. [30]

Root conditioning

Chemical root-surface conditioning using a variety of agents has been introduced in order to detoxify, decontaminate and demineralize the root surface, thereby removing the smear layer and exposing the collagenous matrix of dentin and cementum. Various acids have been used for chemical root-surface conditioning, including citric and phosphoric acids, ethylenediaminetetraacetic acid and tetracycline hydrochloride. In an animal model, these procedures are believed to be able to induce cementogenesis and enhance attachment by connective tissue ingrowth and/or demineralization. In human studies, no clinical advantages were observed [31]. The clinical relevance of root conditioning with an acid agent in routine periodontal surgery is still uncertain, and there is no evidence that these products will improve root coverage.

Healing after root coverage procedures

The major goal of periodontal plastic surgery is the coverage of roots exposed by gingival recession. These days, the covering of denuded roots is a predictable and effective procedure, usually with highly esthetic results. The nature of the attachment between the grafted tissue and the root surface is not well understood, and a potential weakness of the

technique is that a pocket may be created where the recession has been covered. A true new connective tissue attachment would be preferable to a long junctional epithelium. Histological evaluation of the nature of the interface between the newly covered root surface and overlying gingival tissues is based on animal studies and isolated case reports.

In animal studies, the healing was characterized by the formation of new cementum and new connective tissue attachment in the apical aspect of the defect and by a junctional epithelium in its most coronal third. When compared with the coronally advanced flap alone, both techniques rendered similar clinical outcomes, although the collagen matrix graft attained more tissue regeneration, with a shorter epithelium and a larger new cementum formation [32, 33].

A human histological case series comparing connective tissue grafts and acellular dermal matrix grafts after 6 months of healing indicated comparable gingival attachment to the root surface (a combination of long junctional epithelium and connective tissue adhesion). The acellular dermal matrix graft seemed well incorporated with new fibroblasts, vascular elements and collagen, whilst retaining its elastic fibers throughout.

The findings of the literature are not conclusive and are sometimes controversial; very few studies, mainly case reports, are available. However, within the limits of the reported studies, it is possible to affirm that the combination of a long junctional epithelium and connective tissue attachment is created when gingival recessions are treated with periodontal plastic surgical procedures. The concentric distribution between connective tissue attachment and long junctional epithelium suggests that regenerative procedures (guided tissue regeneration or enamel matrix derivate) could be appropriate, preferably in wide defects or in the case of a buccally dislocated root with larger root exposure with respect to bone position. The variability of the results in the reported studies indicates that further histological investigations are needed. [6, 30, 34, 35]

CONCLUSION

Surgical coverage of gingival recession is very predictable, at least for a single type of defect. The gold standard is the bilaminar technique, which mainly consists of a coronally advanced flap covering a connective tissue graft because the adjunctive use of connective tissue grafts increases the likelihood of achieving complete root coverage, with respect to the use of the coronally advanced flap alone, especially in long-term follow-up.

Studies are needed to clarify, in greater detail, which, and how many, gingival recessions should be treated with the adjunctive use of connective tissue grafts when treating multiple gingival recessions. The utilization of substitutes for the connective tissue grafts would be strongly encouraged. Despite recent improvements, none of the available allograft materials can be considered as a true substitute for connective tissue grafts.

One of the most important innovations in gingival recession treatment, which has already started but needs future development and improvement, is the design of clinical trials with the patient's outcome, esthetics and morbidity in

particular, as primary outcome measures. This is likely to change current success evaluation criteria and also the decisional matrix in the surgical management of gingival recession.

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