Decision making in periodontal plastic surgery

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Abstract

Preserving periodontal soft tissues (ST) is crucial to ensure long-term stability of dental health. Gingival recession (GR) can lead to both functional and aesthetic challenges, often necessitating surgical solutions. Techniques such as the coronally advanced flap (CAF), either alone or combined with grafts, have been documented as practical approaches. However, a significant drawback of autogenous grafts is the harvesting process, which extends the healing time at the donor site and increases patient discomfort. This study aims to evaluate the most reliable methods for addressing graft rejection (GR) using cellular allografts (CAF) along with a novel xenogeneic acellular dermal matrix (xeno-ADM), providing insight and guidance for clinicians in their decision-making process. A literature review was conducted from March to June 2020, using PubMed, the Cochrane Library, and manual searches of key journals, including the Journal of Periodontology, International Journal of Periodontics and Restorative Dentistry, Journal of Clinical Periodontology, and Journal of Periodontal Research. The investigation explored GR classification systems, surgical flap designs for root coverage procedures (RCP), and the graft types used in these interventions. All reviewed RCP techniques demonstrated reductions in recession depth (RD) and gains in clinical attachment level (CAL), making them viable for clinical use. Both CAF and tunnelling techniques are skill-intensive and require practice to achieve full root coverage. Xeno-ADM (NovoMatrix) emerges as a promising substitute for subepithelial connective tissue grafts (SCTG), offering ease of use, unlimited availability, reduced postoperative morbidity, rapid vascularization, and excellent tissue integration. However, additional research is warranted to assess its long-term stability at least one year after surgery.

Keywords: Gingival Recession (GR), Coronally Advanced Flap (CAF), Subepithelial Connective Tissue Graft (SCTG), Xenogeneic Acellular Dermal Matrix (XADM)

Introduction

Ensuring the integrity of periodontal soft tissues (ST) is vital for maintaining predictable dental health over time (1). Gingival recession (GR), characterised by the apical displacement of the gingival margin past the cementoenamel junction (CEJ), exposes the root surfaces and can result in functional and aesthetic concerns that require surgical correction (2, 3). The causes of GR are multifaceted, including factors such as bone dehiscence, tooth misalignment, plaque buildup, improper brushing techniques, trauma, poorly designed restorations, orthodontic therapy, previous surgeries, and inadequate ST width or thickness (4–8). To categorise these defects, Miller introduced a classification that divides marginal gingival recessions (MGR) into four groups

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based on periodontal tissue involvement, including the mucogingival junction (MGJ) and alveolar bone. Although this system assesses the extent of tissue damage, it overlooks characteristics of the root surface, such as CEJ visibility or root abrasion, which may coexist with enamel wear (9). The identification and position of CEJ are critical to determining the success of root cover surgeries (10, 11). Subsequent updates to Miller's classification have incorporated additional periodontal factors, improving diagnostic precision for GR types (12, 13). GR often affects aesthetics and causes dentin hypersensitivity, forcing patients to seek treatment for single or multiple buccal recessions (14, 15). The goal of root coverage procedures (RCP) is to fully resolve gingival recession (GR) defects, achieving minimal post-treatment probing depths and soft tissue contours that blend seamlessly with the surrounding areas (16–18). Various RCP techniques exist, including rotational flaps (e.g., flaps with laterally positioned or double papillae) and advancement flaps, such as the CAF, which can be used alone or with grafts (19, 20). CAF in combination with a subepithelial connective tissue graft (SCTG) is widely considered the benchmark for GR treatment (21, 22). However, the harvesting of autogenous tissue prolongs donor site healing and increases patient morbidity, with reports of persistent pain and numbness after surgery (23, 24). Anatomical restrictions, such as the shape of the palatal vault, the patient's age, sex, and proximity to palatal nerves and vessels, further limit the availability of grafts (25). To address these challenges, alternatives such as alloplastic materials and xenografts, including acellular dermal matrices (ADMs), have been developed; however, they offer limited volume enhancement (26–28). With personalised medicine in mind, tailoring surgical strategies to individual patient profiles can enhance results (29). This study evaluates reliable GR treatment options using CAF with a new xeno-ADM, aiming to support clinicians in decision-making.

Materials and Methods

A comprehensive review of the existing literature was conducted between March and June 2024, exploring multiple sources: 1) PubMed; 2) the Cochrane Oral Health Group Specialised Trials Registry within the Cochrane Library; and 3) manual exploration of prominent journals, including the Journal of Periodontology, International Journal of Periodontics and Restorative Dentistry, Journal of Clinical Periodontology, and Journal of Periodontal Research. The investigation focused on three key areas: classifications of gingival recession (GR), surgical flap designs used in root coverage procedures (RCP), and types of grafts suitable for RCP.

Results and Discussion

Recession Classification

Classical Miller classification

Miller's system organises gingival recession into four categories:

- **Class I:** Recession of marginal tissue that stops short of the mucogingival junction (MGJ), without loss of interdental bone or soft tissue; complete root coverage is expected.
- **Class II:** Recession reaching or surpassing the MGJ, yet without loss of interdental tissue; full root coverage remains achievable.
- **Class III:** Recession extending to or beyond the MGJ, accompanied by loss of interdental bone or soft tissue or tooth malposition, limiting coverage to partial success, which can be assessed presurgically with a periodontal probe.
- **Class IV:** Severe recession past the MGJ with significant loss of interdental tissue and/or tooth malposition, making root coverage unfeasible (30). Despite its widespread use, this framework is unreliable and invalid, which is critical for practical clinical assessment.

Nordland and Tarnow Classification

Introduced in 1998, Nordland and Tarnow proposed a system to evaluate papillary height loss based on three distinct anatomical markers:

1. The point of interdental contact,
2. The apical limit of the facial cementoenamel junction (CEJ),
3. The coronal boundary of the interproximal CEJ. Although this approach is straightforward and practical, it lacks comprehensive detail.

Mahajan Classification

In 2010, Mahajan revised Miller's classification to address its shortcomings, including limited depth and the inability to distinguish between Classes III and IV solely by the severity of recession, as well as to evaluate interdental bone and soft tissue loss thoroughly. Building on these observations, Mahajan introduced refined criteria: separating the extent of the recession relative to MGJ from the loss of interdental tissue and adding objective measures to differentiate severity in Classes III and IV (13). The updated categories are as follows:

1. **Class I (M I):** Recession not reaching the MGJ.
2. **Class II (M II):** Recession extending to or past the MGJ.
3. **Class III (M III):** Recession with loss of interdental bone or soft tissue up to the cervical third of the root, or tooth malposition.
4. **Class IV (M IV):** Recession with severe loss of interdental tissue beyond the third cervical and/or pronounced malposition. A prognostic guide accompanying this:
    - **Best:** Classes I and II with thick gingival tissue.
    - **Good:** Classes I and II with thin gingival tissue.
    - **Fair:** Class III with thick gingival tissue.
    - **Poor:** Classes III and IV with thin gingival tissue. Based on Miller's well-known system, Mahajan's adaptation facilitates adoption by clinicians accustomed to the decades-old standard.

Cairo Classification

Cairo et al. (2011) developed an alternative system identifying three types of recession (RT) based on interproximal attachment status (31):

- **Recession Type 1 (RT1):** Gingival recession without loss of interproximal attachment; the interproximal CEJ remains clinically undetectable mesially and distally.
- **Recession Type 2 (RT2):** Recession with loss of interproximal attachment not exceeding loss of buccal attachment (measured from CEJ to pocket depth).
- **Recession Type 3 (RT3):** Recession in which the loss of interproximal attachment surpasses the loss of buccal attachment. For cases where root coverage is feasible (eg, Miller's Classes I/II, Mahajan's M I/M II, Cairo's RT1/RT2), clinicians must categorise patients by specific factors to choose an appropriate technique (32–34) (Figure 1):
- **Keratinised Tissue (KT) Apical to GR:** Present or absent. If absent, a two-stage approach is required, involving the initiation of KT with a free gingival graft, followed by a coronally advanced flap (CAF). A minimum of 1.5 mm KT is required for a single-stage procedure (35).

Gingival biotype: Thin, Medium Thick, Thick
Gingival thickness below 1 mm correlates with a lower likelihood of achieving full root coverage using advanced flaps alone (36). The contour and thickness of the tissue play a crucial role in the outcomes: thicker tissues and abundant residual KT improve the results. Clinicians opt for CAF or sliding flaps when KT is sufficient, or add a graft beneath the flap if the tissue thickness is inadequate to support the flap (37).

Demand for aesthetic patients: High or Low
Aesthetic considerations, particularly in smile design, are increasingly central to dental practice. The key elements influencing smile aesthetics include the facial midline, the smile line, papillary recession, tooth size, shape, position, colour, gingival framework, and lip structure (38–40).

Grafts

Autologous SCTG
Composition
The hard palate masticatory mucosa (MMhP) consists of three distinct histological layers:

- The epithelial layer,
- The subepithelial connective tissue, including the lamina propria,
- The submucosal layer. The epithelium, which can reach a thickness of 300 micrometers, closely resembles the structure of the gingival epithelium. Under it, the lamina propria is a robust tissue rich in intercellular components, primarily composed of collagen fibrils. This layer is subdivided into a papillary segment and a denser reticular segment, characterized by thick reticular fibers. The submucosa, a connective tissue band, links the lamina propria to the underlying periosteum and contains glands, nerves, and adipose tissue (41). The thickness and makeup of MMhP differ between individuals and anatomical sites. The tuberosity region typically exhibits the highest thickness, exceeding 4 mm, while the palatal mucosa near the second and premolars averages around 3 mm (42).

Anatomical landmarks
The blood supply to the palate originates from the greater palatine artery (GPA), a branch of the maxillary artery, exiting via the greater palatine foramen. The GPA travels along a groove lateral to the greater palatine nerve (GPN), distributing branches to the palatal mucosa and gingiva, and gradually narrows until it connects with the sphenopalatine artery in the

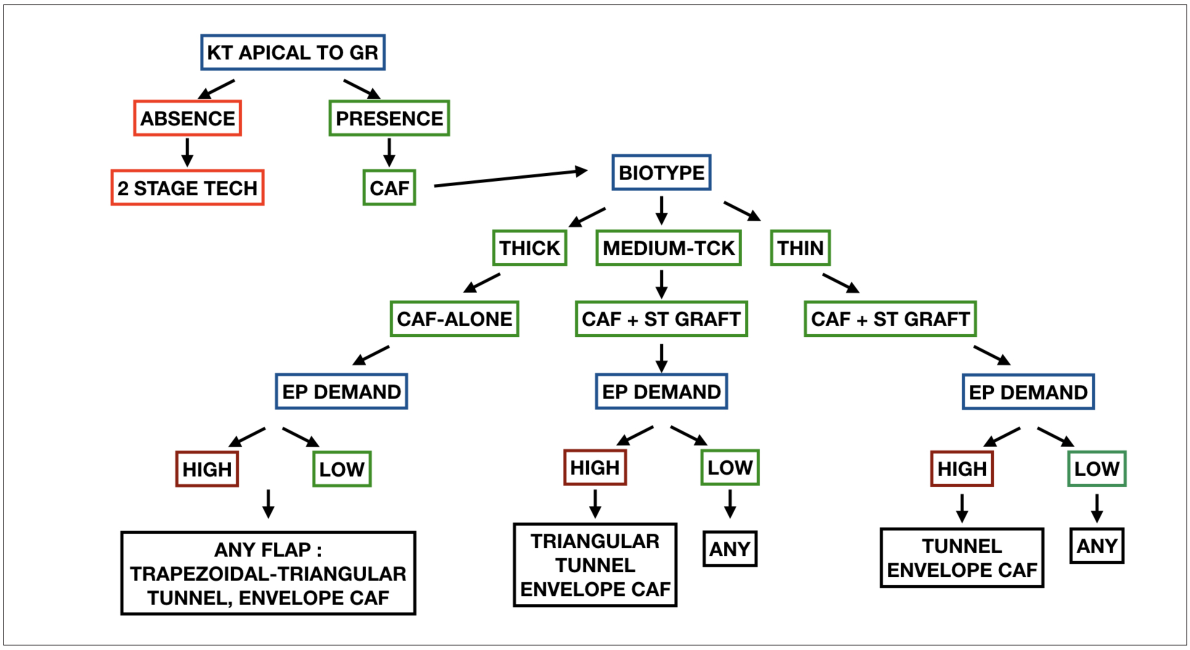

Figure 1.

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incisive canal. Innervation of the palatal gingiva and mucosa is provided by the GPN, which also emerges from the greater palatine foramen and runs medial to the GPA. A palpable crest typically separates these two structures clinically (43).

Donor sites

Preferred sites for autograft harvesting include the anterior and posterior palate, with the latter further divided into tuberosity and lateral regions. Tuberosity grafts tend to be bulkier, while posterior lateral palate grafts are thinner, and anterior palate grafts often provide a larger surface area, which influences their clinical applications. These grafts vary histologically, affecting both volume retention and revascularisation. Clinical observations suggest that the subepithelial connective tissue of the tuberosity and posterior lateral palate is firmer and denser than that of the anterior palate, which may reduce postoperative shrinkage. However, denser grafts may be more prone to necrosis compared to anterior palate grafts. In particular, posterior palate grafts typically require full flap coverage for primary healing, unlike anterior grafts. Consequently, lateral and anterior palate grafts may be better suited for root coverage than tuberosity grafts (44–47).

Soft tissue substitutes

Options include:

- Allogenous acellular dermal matrix graft (ADMG) (48),
- Xenogeneic collagen membranes (VCMX),
- Enamel matrix derivative (EMD) (49),
- Collagen bilayer matrix graft (XCM) (50),
- Xenogeneic acellular dermal matrix (XADM). NovoMatrix, a porcine-derived acellular dermal matrix, represents an advance in xenogeneic technology by providing an intact scaffold through specialised processing. This method preserves structural integrity, promoting regeneration through rapid revascularisation, fibroblast infiltration, and minimal inflammation, which ultimately integrates as host tissue for durable repair (51; 52). Supplied prehydrated in a phosphate-buffered aqueous solution with stabilizers, it requires no extensive preparation. Preclinical and in vitro studies highlight its low immunogenicity, minimal foreign body reaction, and effective collagen organisation (53–55).

Description of autologous SCTG harvesting techniques

Considering Anatomical Landmarks

Four-incision or rectangular graft technique

After assessing the palatal sulcus (in the presence of teeth or implants) and identifying key anatomical features (arteries and nerves), a rectangular outline is created with two parallel mesiodistal incisions and two vertical cuts. The graft is extracted using a blunt tool (including the periosteum) or by partial dissection with a scalpel, resulting in a rectangular free gingival graft (FGG). Outside the mouth, the epithelium is removed with a bi-spray blade to produce an SCTG (52). An alternative approach involves intraoral abrasive de-epithelialization using a high-speed diamond bur, accompanied by ample irrigation, until a bleeding surface appears (56).

Trap Door Technique

This method involves one horizontal incision and two vertical incisions to access the tissue. A partial thickness flap is elevated, approximately 1 mm thick and composed mainly of epithelium and subepithelial connective tissue. The graft can then be harvested in full thickness (with periosteum) or partial thickness (without periosteum), removed, and the site closed by repositioning the pedicle flap (57, 58).

One-incision technique

The aim here is to form a uniform, 1- to 1.5-mm-thick partial-thickness mucosal flap tailored to the recipient site's needs. A single horizontal incision is made with a bi-styrene blade at a 90-degree angle to the bone. Submining begins from this cut, gradually flattening the angle of the blade with each pass until it aligns nearly parallel to the bone surface. The underlying connective tissue graft (CTG) is isolated by incising the bone on the mesial, distal, and medial sides, then detached from the bone using a periosteal elevator for removal.

3.5 Coronally Advanced Flap

Technique Description

Trapezoidal CAF single recession

The procedure begins with the identification of the CEJ and measurement of the distance to the most coronal edge of the recession using a periodontal probe. Coronal flap displacement (CFD) is determined by adding 1 mm to this measurement (CFD = CEJ to coronal GR limit + 1 mm). This value is marked apically from the tips of the mesial and distal papillae (Figure 2a). Then, a 3mm mesiodistal incision is made from the sulcus at these points (Figures 2 b-c). If the tips of the papillae lie on different planes, the incision levels adjust accordingly. At the edges of the horizontal incision, two slightly divergent vertical incisions are made in a coronapical direction, extending 3-5mm past the mucogingival junction (MGJ) to form a trapezoidal flap and define surgical papillae (Figure 2d). The surgeon probes the apical tissues of the GR, deflecting the partial thickness of the surgical papillae to this limit (Figure 2e). The apical KTKT to the GR is elevated full thickness, extending 3 mm beyond the buccal bone crest using a periosteal elevator (Figure 2f). Furthermore, partial-thickness deflection facilitates CFD. Anatomical papillae are deepithelialised with a bifurcated blade or microsurgery scissors (Figure 2g). The flap is sutured coronally with interrupted stitches, beginning at the apical ends of the vertical incisions, first mesioapically, then distoapically, alternately progressing toward the base of the surgical papillae, where a single sling suture secures them (Figure 2h) (56).

Triangular CAF single recession

To determine the initial points for the two oblique incisions, an orthodontic wire is used to measure a curved line

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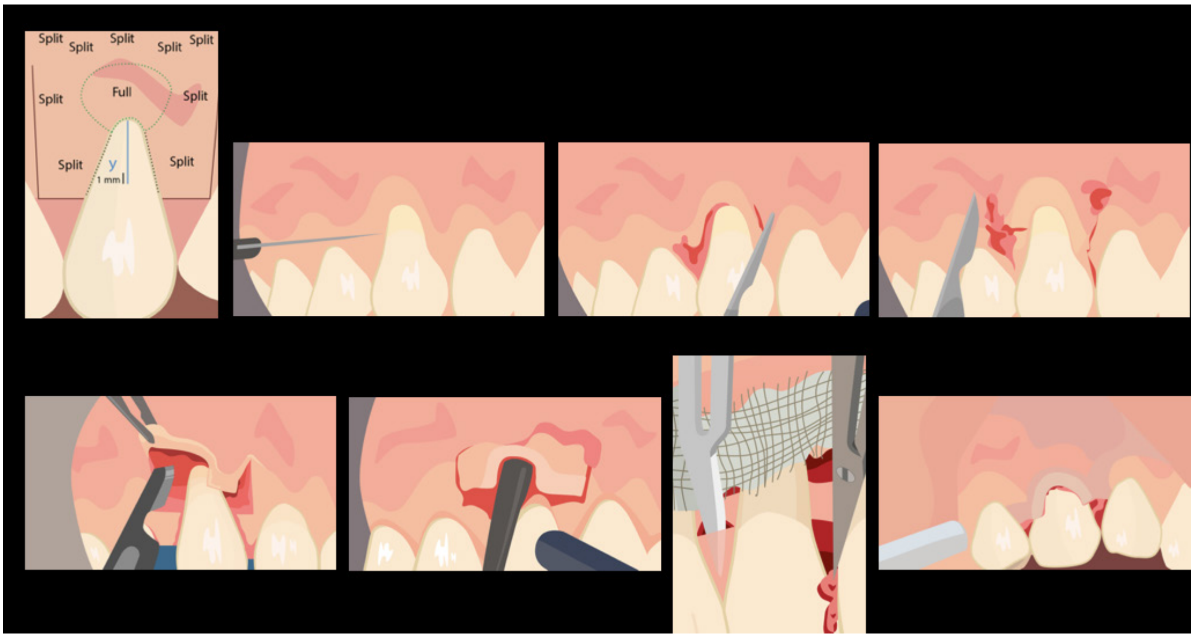

Figure 2. Step by step trapezoidal caf surgery illustration: a)mapping; b)horizontal incision; c)intrasulcular incision; d) vertical releasing incisions are performed on the mesial and distal aspect beyond the mucogingival line; e) partial thickness dissection is performed with a bistoury blade; f) full thickness dissection is performed with a periosteum elevator according to the schematic drawing; g) anatomical papillae desepithelization is carried on with a bistoury blade and microsurgery precision scissors; h) after securing mesial and distal releasing incisions with simple stiches, CAF is sutured 1 mm coronal to the CEJ through a unique sling sutures.

running parallel to the cementoenamel junction (CEJ). This line connects the tips of the papillae, with its deepest point at the midpoint, positioned 1 mm coronal to the CEJ. This measurement defines the perimeter of the flap necessary for coronal advancement. The wire is then repositioned to align with the most coronal boundary of the gingival recession (GR), and each half is shaped to follow the gingival margin of the recession. Then, two oblique vertical incisions are made, starting from the end points of the wire and extending parallel to the soft tissue edges of the neighbouring healthy teeth. This ensures that the surgical papillae mirror the shape of the anatomical papillae, with incisions reaching 3 mm beyond the mucogingival junction (MGJ) (Figure 3). The flap is elevated in the same manner as described for the trapezoidal flap technique. In this approach, deepithelialization of the anatomical papillae covers the entire overlapping region, making it more extensive than in other methods. The suturing process follows the same steps as described for the trapezoidal CAF (59).

Envelope CAF (multiple adjacent recessions)

To prevent scarring and enhance blood flow, vertical release incisions are avoided at the mesial and distal sides. Instead, the incisions are expanded to encompass one additional tooth on either side of the treatment area, helping to achieve the intended coronal shift of the flap over the exposed root surfaces. The horizontal incision of the envelope flap comprises oblique submarginal cuts in the interdental spaces, seamlessly transitioning to intrasulcular incisions at the recession sites. Initial cuts are made to the mesial and

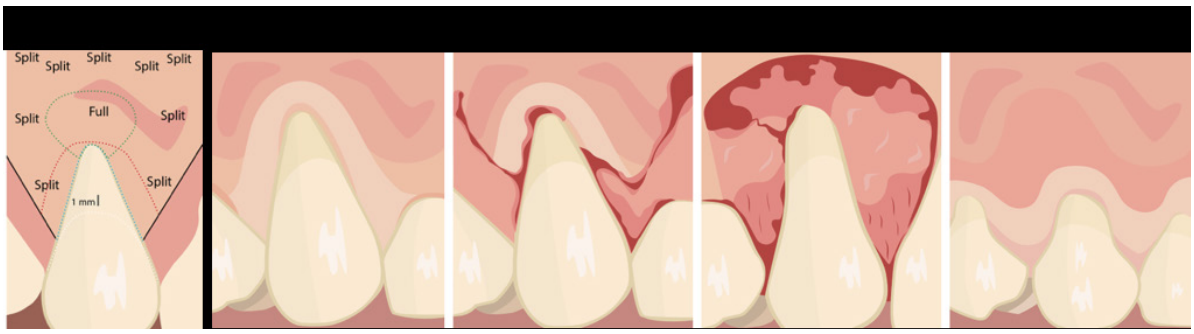

Figure 3. a) triangular caf single recession mappin, red interrupted line is flap perimeter extension, green interrupted line represents the oblique releasing incision starting point, is defined bending the wire along the gingival recession; b) initial clinical situation; c) incisions; d) flap deflection according to the schematic drawing on different planes, partial and full thickness; e) final clinical situation.

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distal surfaces of the tooth with the most pronounced recession defect (RD). To establish the starting point for these incisions, the recession is measured, and 1 mm is added to this value. This distance is then marked in the sulcular regions of the mesial and distal teeth, beginning at the tips of the respective papillae. The incisions follow an oblique trajectory from the apical peak of the recession on the adjacent teeth to these predetermined points (Figure 4a). For adjacent teeth, a single incision is made on the mesial side for the mesial tooth and the distal side for the distal tooth. This process is repeated, recalculating the origin of the incision based on each tooth recession defect (Figure 4b). The boundaries are established at the central incisors and the first molar, provided that the recession of the mesial root in the latter is less than 1 mm. The oblique submarginal interdental incisions displace each surgical papilla (SP) relative to its anatomical counterpart. The envelope flap is elevated using a split-full-split technique from coronal to apical: the oblique interdental cuts are executed with the blade aligned parallel to the long axis of the tooth, allowing for a split-thickness dissection of the surgical papilla (Figure 4d). The gingival tissue below the exposed roots is lifted as described for single-defect cases (Figure 4e). Lastly, the most apical section of the flap is raised in a split-thickness fashion to support coronal repositioning. The remaining anatomical interdental papilla tissue is removed to form connective tissue beds for suturing the surgical papillae (Figure 4f).

A precise incision will be made in the mucosa of the vestibular lining to relieve muscle tension. It is essential to recognise that achieving proper coronal flap displacement depends on releasing lip and muscle tension in the apical region. Single sling sutures will be used to anchor the buccal flap to exposed root surfaces and to stabilise each surgical papilla on the bed of interdental connective tissue. The buccal flap will eventually be placed 1 mm coronal to the cementoenamel junction (CEJ) (Figure 4g). Furthermore, apically, a horizontal double mattress suture should be applied to minimise lip tension along the marginal edge of the flap (59-60).

CAF + STG

The recipient site is prepared using one of the previously outlined methods, such as triangular or envelope CAF, depending on the chosen flap design. Before repositioning the flap to its intended location, the graft must be fixed in place. The dimensions of the graft should adhere to these specifications:

- a height 1 mm greater than the gingival recession (GR) defect,
- a width 6 mm larger than the mesiodistal recession span at the CEJ,
- A thickness of 1 to 1.5 mm. The graft is attached 1 mm coronal to the CEJ using two interrupted sutures, placed at the surgical papillae bases or to the keratinised tissue (KT) of adjacent healthy teeth, one on the mesial side and one on the distal side. The flap is then sutured back into position following the steps detailed in the earlier CAF techniques.

Tunnel technique (single or multiple recession)

This surgical technique involves placing a soft tissue graft (STG) into a recipient bed configured as a single envelope (for a solitary recession) or multiple envelopes (for adjacent recessions), known as a tunnel. The tunnel consists of a supraperiosteal space beneath a pedicle flap, created without the need for external incisions. The STG is inserted and fixed within this tunnel to cover the exposed roots in the vicinity. A partial thickness sulcular incision is made using a 15c blade along each margin of the gingival recession (GR), aligned parallel to the wall of the buccal bone and

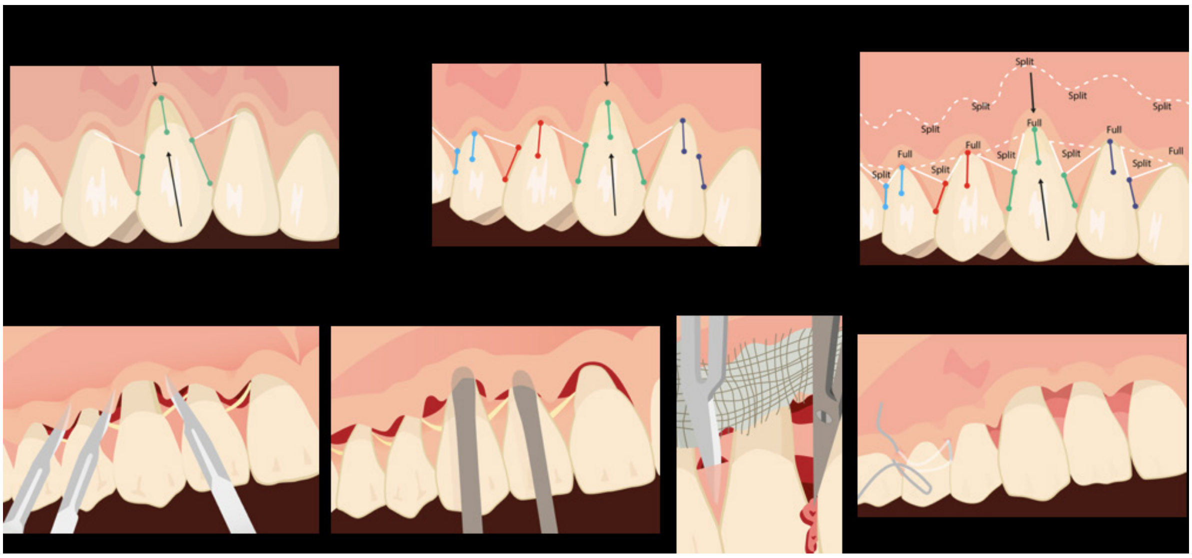

Figure 4. Step by step envelope caf surgery illustration; a-b-c) mapping and initial situation; d) partial dissection on the mesial and distal aspect of each recession; e) full-thickness dissection apical to each recession carried on with a periosteum elevator; f) anatomical papillae dissection carried on by a bistoury or microsurgery scissors; g) sling sutures are carried on securing coronal advancement than simple suture are performed to ensure the surgical papillae.

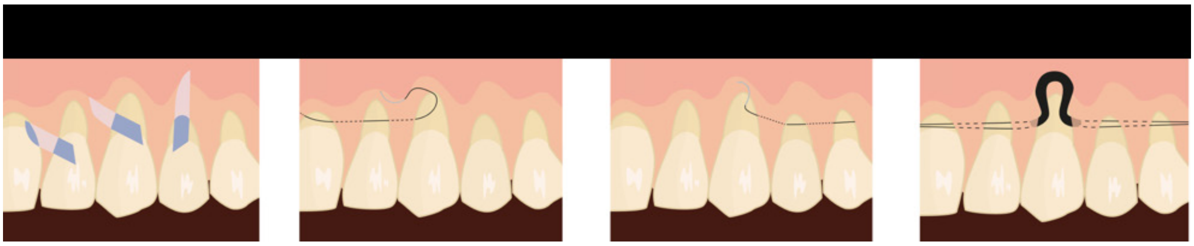

Figure 5. Schematic drawing of tunnel technique; a) partial dissection using a bistoury blade b) introducing the first needle underneath the distal recession till the most extended one; c) introducing the second needle underneath the mesial recession till the most extended one; c) the graft is secured at the distal and mesial aspect with vertical open mattress stiches by these 2 sutures already inside the tunnel.

extending 1 to 2 mm past the mucogingival junction (MGJ). This incision ensures sufficient relaxation of the pedicle flap to accommodate the STG, which can be either a subepithelial connective tissue graft (SCTG) or a xenogeneic acellular dermal matrix (XADM) within it. The partial dissection extends laterally through the base of the papillae of the affected teeth without completely cutting them. Papillae deflection is prohibited; if it occurs, the procedure must be stopped. The dissection continues 3 to 5 mm mesially and distally toward adjacent healthy teeth to properly position the mesial and distal edges of the STG (Figure 5a). Caution is essential when crossing the MGJ to prevent flap perforation, particularly in the premolar and canine areas of both jaws, where pronounced convexities increase this risk if only a bi-shaft blade is used. A critical aspect is maintaining a single and uniform dissection plane throughout the tunnel. To confirm the smooth passage of the STG, the dissection plane can be inspected using a periodontal probe or an Orban knife (standard or inverted); no resistance, such as frenula, periosteal attachments, or muscle, should be encountered when advancing the probe. Any obstacles must be cleared, typically by applying

Figure 6. Double recession case report in the aesthetic area solved with a XADM Novomatrix Biohorizont graft in a tunnel technique; a) initial situation, thin scalloped biotype, tooth 1.1 3 mm recession, tooth 2.1 1.5 mm recession, both Miller class 1; b) a perioprobe is used after tunnel performing to check dissection planes and flap mobility advancement; c) graft introduction, XADM Novomatrix graft; d) final clinical situation after surgery; e) 1 week follow up; f) 2 weeks follow-up; g) 3 weeks follow up; h) suture removal at 3 weeks follow up; i) 6 months follow up; l) 8 months follow-up after aesthetic reconstruction; m) coronal picture assessing the horizontal stability and checking the maintenance of the medium thick biotype reached along time at 1 year; n) before and after

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traction with the probe to release these structures. Two initial sutures are placed using separate needles: one at the most mesial point of the tunnel and another at the most distal (Figure 5b). Each needle passes beneath the partial flap and exits through the most significant or most centrally located recession, where the STG will be inserted. Using these pre-placed sutures, the graft is anchored at its mesial and distal ends with vertical open mattress stitches (Figure 5c). Once secured on both sides, the graft is gently positioned in the tunnel by applying pressure with a blunt instrument while simultaneously pulling the sutures from the mesial and distal ends, allowing it to slide smoothly into place. If the flap is adequately lifted, the STG will rest coronal to the cementoenamel junction (CEJ), and the vertical mesial and distal sutures of the mattress can be tightened and finalised (Figure 5d). A simple square knot, using resorbable sutures, secures the graft in its intended coronal-apical orientation (61–64).

Conclusions

Accurate diagnosis of a recession defect is crucial for determining the feasibility, timing, and approach of surgical interventions. The presence of keratinised tissue, the patient's gingival biotype, and their aesthetic preferences directly shape the choice of surgical method. Referring to the BEK decision tree (Figure 1), clinicians can tailor treatment strategies to individual patient profiles, improving outcomes and reducing failures due to inadequate diagnostic or decision-making processes. All evaluated root coverage procedures contribute to reducing the depth of recession (RD) and enhancing the level of clinical attachment (CAL), making them viable options for clinical application. However, techniques such as coronal advanced flaps (CAFs) and tunnelling approaches demand technical precision, which requires a period of skill development to achieve full root coverage.

The subepithelial connective tissue graft (SCTG) remains the benchmark for these procedures to date. However, its harvesting process faces several constraints.

- Dependence on the clinician's expertise (technically demanding),
- restrictions posed by donor site anatomy,
- Patient-related challenges (limited tissue availability and postoperative morbidity),
- Extended duration of operation.

On the contrary, the xenogeneic acellular dermal matrix (XADM), specifically NovoMatrix, offers a promising substitute for SCTG. Its advantages include ease of use, an unlimited supply, the absence of harvesting-related postoperative complications, rapid vascularization, and effective tissue integration, making it well-suited for root coverage procedures. Nevertheless, further research is needed to evaluate its long-term stability, particularly beyond two years postoperatively.

Conflict of Interests

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