Coronally Positioned Flaps and Tunneling

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9.1 Introduction

Patients often present with a variety of soft tissue defects around teeth and implants that can lead to functional and esthetic problems. An array of surgical procedures has been developed to manage these soft tissue defects. The initial procedures were mainly resective in nature and aimed at correcting aberrant frenum attachments, shallow vestibules, and inadequate attached gingiva. These procedures were collectively referred to as "mucogingival surgery" [1]. In recent years, surgical procedures to deal with soft tissue deficiencies have been refined and have incorporated regenerative therapies, as well as adopted the goal of esthetic enhancement. This broadening of the range of surgical procedures leads to the introduction of "periodontal plastic surgery," as a new term, coined by Miller [2]. Soft tissue abnormalities could be treated in a predictable manner, improving soft tissue health, function, and esthetics [3].

9.2 Scope of the Problem: How Common Is Gingival Recession?

Gingival recession is characterized by apical migration of the gingival margin from the cementoenamel junction (CEJ), with concomitant exposure of the root surface. The root exposure associated with gingival recession can have negative

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esthetic sequelae, as well as predispose the site to dentinal hypersensitivity and root caries [4].

The prevalence of gingival recession can vary substantially among the specific study populations. In North America, it has been described in one epidemiological study in 78–100% of middle-aged individuals, potentially affecting 22–53% of the teeth [5]. In another study, the prevalence of 1 mm or more recession in American population aged 30 years and older was 58% and increased with age [6]. In Brazil, a more recent study showed that 89% of the adults presented with gingival recession [7]. In addition, other epidemiological studies demonstrated that adult subjects showed a prevalence of gingival recession of 51% in Norway [8] and of 68% in Finland [9]. Overall, gingival recession is a highly prevalent condition, which progressively increases with age.

9.3 Etiology

The identification of potential etiological factors in the induction of gingival recession is critical in managing those risk factors in the course of therapy. The literature has described many possible factors, though their causality has not been established. Anatomical, physiological, pathological disease-related, and mechanical factors have been suggested [10, 11].

Periodontal or tooth anatomy can play a role in the apical migration of the gingival margin. Inadequate zone of attached gingiva, high frenum or muscle insertions, tooth malalignment, and excessive root prominences with associated thin alveolar bone are believed to predispose to the development of recession. Ectopic positioning of roots outside of the alveolar bone envelope, following orthodontic tooth movement, may also lead to gingival recession. Mechanical trauma encompasses various forms of injury to the tissue, including improper tooth brushing, intraoral piercings, prosthetic appliances, aggressive tooth preparation procedures, overhanging restorative margins, invading the biologic width, and tobacco chewing.

Pathologic conditions, such as inflammation associated with periodontitis, lead to apical migration of periodontal attachment and in some cases, resulting in gingival recession.

Successful therapy is predicated on effective removal of the causative factors prior to any periodontal plastic procedure to avoid recurrence.

9.4 Risk Assessment

In addition to the etiological factors, there are certain patient- and site-related factors that can put patients at a greater risk for developing gingival recession. Increased age, male gender, high plaque index, tobacco smoking, and number of missing teeth are patient-related factors that have been associated with the extent and severity of gingival recession [12, 13]. Malpositioned teeth (rotated or too buccally/lingually inclined), teeth with a thin gingival biotype, with excessive frenum pull, with advanced periodontal disease, and/or with subgingival restorative margins have also been correlated with a higher possibility of gingival recession. Although each of these factors has been associated with gingival recession, the presence of multiple factors may significantly increase the risk of developing or exacerbating gingival recession. Therefore, risk assessment should consider each of the elements as well as the number of risk indicators identified in order to develop an effective strategy to mitigate those risks.

9.5 Classification of Gingival Recession Defects

Different classification systems have been used throughout the years to describe gingival recession. Initial attempts at classification measured recession width and depth to classify recession into four categories using the descriptive terms "shallow," "deep," "narrow," and "wide" [14]. The index of recession (IR) was later introduced and was mainly used in cross-sectional and longitudinal epidemiological studies to describe the prevalence, incidence, and severity of gingival recession [15]. It categorized recession by two digits, separated by a dash, such as "F3–6." The letter F or L referred to facial or lingual recession, respectively. The digits denote the horizontal width and vertical height of the recession. The classification proposed by Miller is currently the most widely used classification [16]. This system is based on vertical soft tissue loss in relation to the mucogingival junction (MGJ), as well as the level of interproximal periodontal tissue loss. It categorizes defects into four classes. Miller Class I describes gingival recession, which ends coronal to the MGJ, whereas the denuded root defect extends to the MJG in Class II. The interproximal attachment and bone are intact in Class I and II gingival recession defects, while it is mild/moderate in Class III and severe in Class IV, extending beyond the midfacial recession. Miller correlated the classification to the expected prognosis of root coverage, where complete root coverage was predicted in Class I and II, while only partial root coverage was expected in Class III defects, and unpredictable outcome was anticipated in Class IV sites.

The scientific community has expressed some doubts of this classification system, including the uncertainty of the amount of interproximal attachment loss, the unknown influence of tooth malposition, and the difficult distinction between Class I and II gingival recession. To solve such limitations, Cairo introduced a new classification system, based on the identification of the interproximal clinical attachment level to predict the outcome of therapy [17]. Three recession categories were described in this classification: RT1, exhibiting no interproximal attachment loss; RT2 showing interproximal attachment loss equal or less than the facial defect; RT3 presenting with interproximal attachment loss greater than the facial defect. The degree of facial root coverage anticipated by the RT classification was projected to be limited by the interproximal attachment level. Therefore, root coverage has been suggested to be more predictable in RT1 and RT2 than RT3.

9.6 Rationale for Therapy

9.6.1 Progression of Gingival Recession with or Without Therapy

Multiple lines of evidence have suggested that gingival recession defects are progressive in nature. A longitudinal study with 12-year follow-up demonstrated that gingival recession increases with age and sites with existing gingival recession are at the greater risk of progression [18]. In a retrospective 10- to 27-year follow-up split-mouth study, gingival recession defects, lacking attached gingiva treated with free gingival graft on one side of the mouth, were compared with untreated contralateral sites [19]. Results demonstrated that treatment was effective, since all treated sites exhibited reduced gingival recession and increased stable keratinized gingiva. In contrast, untreated sites showed increased gingival recession during follow-up period.

A systematic review and meta-analysis of untreated gingival recession defects has indicated increased risk of progression of recession during long-term follow-up [20]. There is also some limited evidence to support a protective role for keratinized gingiva in reducing the likelihood of gingival recession progression. As a result, the surgical correction of these defects via soft tissue augmentation and root coverage appears as an important intervention to be considered during the clinical decision-making process.

There are four main indications for the surgical treatment of gingival recession [21–23]:

1. Esthetic purposes
2. To reduce dentinal hypersensitivity
3. To augment a deficient keratinized tissue
4. To correct root abrasion defects or caries

Esthetic Reasons

The main reason that drives many patients to seek periodontal treatment are esthetic concerns. Patients demand treatment when excessively long teeth and/or a lack of harmony in the gingival margins are evident while smiling. The most feasible treatment to correct this esthetic gingival imbalance is root coverage procedures. A recent systematic review of randomized controlled trials demonstrated that periodontal plastic surgery procedures for the treatment of single and multiple gingival recessions improve esthetics, both perceived by patients and objectively assessed by professionals [24].

Hypersensitivity

Teeth with gingival recession often experience pain in response to thermal, chemical, and tactile stimuli to the exposed dentine. This phenomenon is known as "dentinal hypersensitivity." The pain is commonly sharp, short, and localized and can severely affect performance of proper oral hygiene. The treatment for dentinal hypersensitivity can be complex and may include local application of desensitizing agents to occlude exposed dentinal tubules for mild cases with no esthetic concerns. Cervical restoration can be performed in cases where there has been enamel loss, exposing dentine coronal to the CEJ. Surgical intervention to achieve root coverage is another strategy, primarily indicated when complete root coverage can be predicted. A systematic review has suggested that there is not enough evidence to prove that mucogingival surgical procedures can resolve dentinal hypersensitivity [25].

This is attributed to the fact that dentinal hypersensitivity has not been consistently evaluated in clinical studies. Nonetheless, several studies have demonstrated improvement in dentinal hypersensitivity. One reason why dentinal hypersensitivity is not consistently resolved is because incomplete root coverage can be associated with residual dentinal hypersensitivity. Therefore, root coverage can be proposed as a viable therapeutic option for patients who complain of dentinal hypersensitivity, only if complete root coverage is technically feasible.

Keratinized Tissue Augmentation

Gingival recession defects with thin, minimal, or no keratinized gingiva have been considered to be at greatest risk of progression [26]. Therefore, keratinized tissue gain has been considered one of the therapeutic objectives of periodontal plastic surgery. However, it may be debatable whether gingival thickness or the keratinized phenotype of the gingiva is the most important element of risk. The fact that many types of grafting, which do not necessarily mediate clinically significant increase in keratinized gingival zone, are associated with periodontal attachment level stability may argue that gingival margin thickness is more important than keratinization phenotype. Moreover, some of the therapies aimed at increasing keratinized gingival zone, such as free gingival graft, are associated with diminished esthetic and suggest a secondary role for keratinized gingiva in periodontal plastic surgery.

Cervical Caries and Non-carious Cervical Lesions

In the elderly population, radicular caries and/or deep root abrasion are common findings and can pose oral hygiene challenges for patients [27]. These can lead to dentinal hypersensitivity and/or endodontic involvement. The combination of root coverage surgery and restorative treatment in these teeth can help prevent future caries development and render an easier situation for plaque control for the patient. However, one needs to consider that dentinal bonding is not as predictable as enamel bonding. Therefore, bonded restorations in dentin may be more prone to leakage or failure.

9.7 Techniques for Gingival Recession Therapy

Multiple approaches to the treatment of gingival recession defects have been described in the literature, including the coronally advanced flap (CAF) with or without an additional graft, intra-sulcular tunneling (IST), pedicle flaps, free gingival graft (FGG), guided tissue regeneration (GTR), and vestibular incision subperiosteal tunnel access (VISTA). Each of these techniques has advantages and disadvantages.

9.7.1 Free Gingival Graft

A number of investigators have pioneered the technique of free gingival graft [28], as well as its application for vestibular extension [29], root coverage [30], and for pre-prosthetic augmentation of attached gingiva [31]. In 1968 Sullivan and Atkins [32] outlined the biologic basis of FGG and the wound healing process, subsequent to FGG therapy.

Free gingival graft offers a number of advantages and disadvantages. The advantages include increase in zone of keratinized attached gingiva and vestibular depth. The disadvantages include limited ability for root coverage and mismatch of surface contour, texture, and color, which can result in compromised esthetics.

The clinical case in Fig. 9.1 illustrates severe gingival recession (Miller Class III and IV recession defects) in the mandibular incisor area, with thin mucosa and

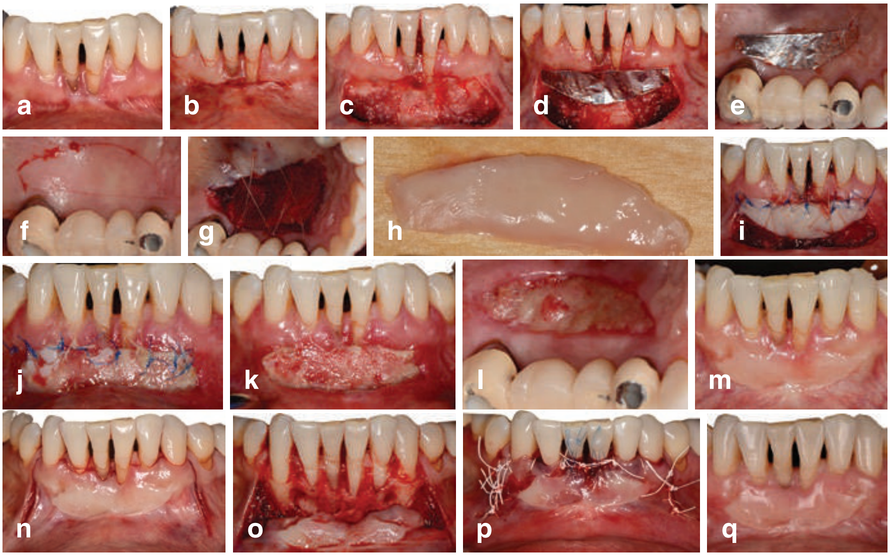

Fig. 9.1 Clinical case of a patient with severe gingival recession defects in mandibular anterior region. The preoperative view shows Miller Class IV in central incisors and Class III recession in lateral incisor area (**a**). Initial horizontal incision was made (**b**), followed by partial-thickness dissection to remove all loose alveolar mucosa, elastic fibers, and muscle attachments (**c**). A template was trimmed to define the planned dimensions of the FGG relative to the recipient bed (**d**) and donor site (**e**). The donor site was outline (**f**), and a thick FGG (approximately 1.5 mm in thickness) was harvested (**g**, **h**) and fixated to the recipient bed (**i**). One week healing results before (**j**) and after suture removal (**k**) showed excellent graft incorporation and donor site healing (**l**). The clinical results after 3 months showed increase in gingival margin thickness and increase in attached keratinized gingiva zone (**m**). To harmonize the gingival margins, coronal positioning of the gingival margins was attempted. A trapezoidal flap was made by two distal vertical releasing incisions (**n**) with split thickness dissection (**o**) and coronal positioning of the flap (**p**). Postoperative results show harmonized gingival margins (**q**). Clinical case, courtesy of Dr. Goncalo Carames

shallow vestibule. The treatment objectives in this case were to increase gingival margin thickness, increase attached gingiva, and deepen vestibular depth. To that end, FGG was performed to increase marginal gingival thickness, which was probably the most important therapeutic objective. In an effort to harmonize the gingival margins, limited root coverage was attempted by coronal positioning of the margin, by coronally advanced flap.

9.7.2 Coronally Advanced Flap

CAF is perhaps the most documented procedure for the treatment of single and multiple gingival recession defects. Norberg is credited as describing a procedure that involved coronal positioning of gingiva. Bernimoulin et al. were the first to report on CAF in 1975 for the treatment of gingival recessions [33]. This procedure has undergone a number of refinements, including by Allen and Miller in 1989 [34], Pini Prato et al. in 1992, Zucchelli and De Sanctis in 2000, and De Sanctis and Zucchelli in 2007. CAF has been performed either without additional graft, subsequent to FGG, in conjunction with a barrier membrane as GTR, or most commonly along with the subepithelial connective tissue graft (SCTG).

The coronally advanced flap for the treatment of single-tooth recession defects is designed with two horizontal beveled interproximal incisions on each side of the recession defect [35]. The incisions are made at a level which measures the recession depth plus 1 mm apical to the papillae tips. Additionally, two relatively short beveled vertical releasing incisions are made. These incisions, which are elevated by partial-thickness dissection, start coronally at the lateral ends of the horizontal incisions and extend apically to the alveolar mucosa. A trapezoid-shaped flap is elevated, starting with partial-thickness dissection of the surgical papilla. Full-thickness flap elevation of the soft tissue apical to the gingival recession zenith is carried out to approximately 3 mm apical to the bone dehiscence. Partial-thickness flap elevation is carried out to mobilize the flap in order to coronally position the flap with minimal tension. The papillae are de-epithelialized in order to create a vascular bed for the elevated flap which will be sutured coronal to the CEJ in the papillae, using sling sutures.

To treat multiple recession defects, interdental submarginal incisions and an envelope flap using split–full–split are employed [36]. The flap is extended at least one to two teeth on either side of the affected teeth to allow for low-tension coronal advancement of the flap.

This technique offers many advantages, including the ability to treat single, as well as multiple recession defects. CAF provides good access to the treatment site, allowing the operator the flexibility to perform full- as well as partial-thickness flaps in an effort to reduce the flap tension for optimal coronal advancement. The main drawback of this technique includes the scar formation associated with the incision line [37]. Previous studies have demonstrated that flap tension is a negative predictor of root coverage, and procedures which reduce flap tension can lead to better root coverage. Similarly, positioning of the gingival margin at least 2 mm coronal to the CEJ can lead to increased likelihood of achieving complete root coverage [38]. One of the major risk factors for root coverage outcome is flap thickness [39]. In cases where flap thickness is less than 0.8 mm, there is decreased likelihood of root coverage. In a recent prospective clinical study, it has been demonstrated that flap thickness was a negative predictor of root coverage only in those cases where CAF was performed without additional graft [40]. In cases where SCTG was used in conjunction with CAF, flap thickness was not a risk factor. Therefore, clinicians can use this information to conclude that in cases with thin mucosa, additional grafting may be utilized.

9.7.3 Intra-sulcular Tunneling (IST)

In 1985, Raetzke pioneered the "envelope" flap that was created by partial-thickness dissection for covering localized areas of root exposure [41]. The envelope flap was formed by an undermining partial-thickness incision in the tissues surrounding the defect and a free SCTG positioned directly over the root dehiscence. In 1994, Allen offered a modification of the Raetzke envelope by creating a partial-thickness supraperiosteal envelope for the treatment of multiple gingival recession defects [42]. This approach entailed partial-thickness undermining dissection through the papillae to allow for coronal advancement of the flap. In 1999 Zabalegui et al. coined "the tunnel" technique by offering a more detailed protocol [43]. This report outlined a strategy to undermine the papillae with partial-thickness dissection through intra-sulcular incision without any surface incisions. The partial-thickness dissection is carried out beyond the mucogingival junction, not to reposition the flap but to allow for insertion of SCTG. Further refinements of the tunnel technique have been offered by coronal reposition of the gingival margin, using double-crossed sutures, which are slung over interproximal embrasures that are blocked with temporary bonded resin restorations [44].

The clinical case in Fig. 9.2 shows a patient with Miller Class I multiple recession defects. Following scaling and root planning, intra-sulcular supra-periosteal tunnel was elevated with the aid of microsurgical blade and extended past the mucogingival junction. A subepithelial connective tissue graft was harvested from the anterior lateral aspect of the palate, inserted into the tunnel, and secured with resorbable 5.0 polyglycolic acid (PGA) sutures. Single sling sutures were performed with 6.0 polypropylene sutures for coronal positioning of the gingival margin. Postoperative follow-up after 2 years shows stable gingival margins with complete root coverage.

Intra-sulcular tunneling has many advantages, including lack of surface incision, which can be less disruptive to the blood supply, potentially leading to faster healing and avoiding esthetic complications. However, the major disadvantages of this technique include the technical challenges of working through the small sulcular area, particularly in cases with exostosis, potentially limiting the ability of flap release.

The clinical case in Fig. 9.3 shows a patient with Miller Class I and II recession defects in the posterior maxilla. The initial presentation shows non-carious cervical lesions. Cervical restorations are noted in various conditions. The restorations in the

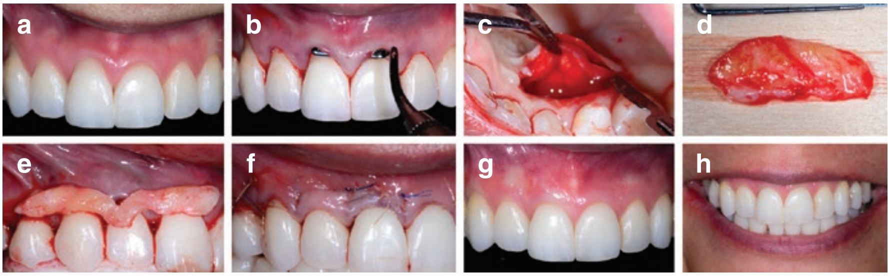

Fig. 9.2 Clinical case of a patient with Miller Class I multiple recession-type defects in the esthetic zone (**a**). Scaling and root planning were performed to remove the biofilm. An intrasulcular tunnel was elevated split thickness from right first premolar to left central incisor (**b**). A connective tissue graft was harvested from the anterior lateral palate (**c**). The connective tissue graft was approximately 2 mm in thickness and 18 mm in length (**d**). A horizontal incision was made in the graft to cover the four teeth with recession defects (**e**). The graft was then inserted into the tunnel through the sulcus of the canine, which had the deepest recession, and secured in position with at the mesial and distal ends with resorbable PGA sutures. Single sling sutures were performed with 6.0 polypropylene sutures for coronal advancement of the final gingival margin (**f**). The 2-year follow-up shows stable gingival margins with complete root coverage (**g**). The patient was satisfied with the esthetic result of the root coverage procedure (**h**)

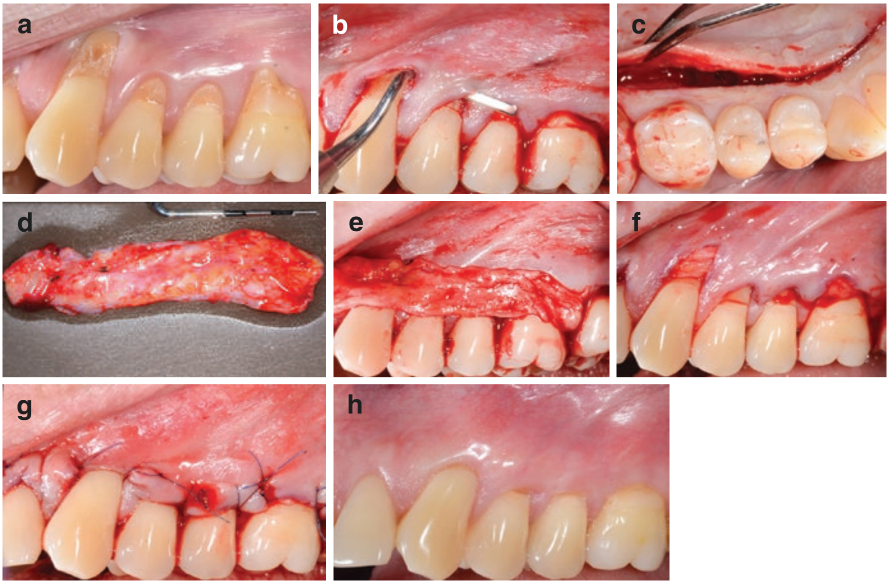

Fig. 9.3 Clinical case of a patient with combination of Miller Class I and Class II recession defects (**a**). Following root preparation, which included scaling and root planning and removal of composite from root surfaces, subperiosteal tunnel was created from sulcular access (**b**). An initial partial-thickness flap was made on the palate to provide access to the subepithelial connective tissue (**c**), which was harvested (**d**). The dimensions of the subepithelial connective tissue graft extended slightly beyond the recession defects laterally and apically (**e**). The subepithelial connective tissue graft was inserted in the tunnel and was positioned at the level of the CEJ (**f**). Gingival margins were coronally positioned, using 6.0 polypropylene sling sutures (**g**). Postoperative results of the case after 3 years with 100% root coverage (**h**)

premolars appear to have fractured off with the only portion remaining adherent to the enamel portion. The restorations in the molar appear to have intact margin in enamel, with leakage in the region extending to the root. These observations verify the point made earlier that dentinal bonding, despite claims to the contrary, is not reliable and often leads to restorations, which leak or are displaced. Some authors have recommended to restore the cervical portions of non-carious cervical lesions prior to surgery and then cover the recession with coronally advanced flap [45]. The problem with this approach is that if part of the restoration, which may be subgingival, may have marginal leakage with resultant gingival inflammation. In the case illustrated in Fig. 9.3, all restorations apical to the CEJ were removed. This was followed by thorough scaling and root planning. Intra-sulcular subperiosteal tunneling was carried out from the gingival sulcus and carried out past the mucogingival junction to achieve passive coronal advancement of the gingival margin. Subepithelial connective tissue graft was obtained from the palate and inserted within the recipient tunnel. The SCTG was positioned as coronally as possible within the tunnel. The gingival margins were subsequently coronally positioned with the aid of sling sutures. Postoperative follow-up after 3 years shows complete root coverage and a stable gingival tissue.

9.7.4 Vestibular Incision Subperiosteal Tunnel Access (VISTA)

The vestibular approach to soft tissue augmentation started with the semilunar coronally positioned flap technique [46]. The approach entailed a semilunar incision made parallel to the facial free gingival margin and coronally positioning this flap over the exposed root. The vestibular approach for bone augmentation has been described by several investigators [47–49]. The vestibular incision and subperiosteal tunneling for soft tissue augmentation have also been reported [50]. The rationale and detailed protocol for VISTA for the treatment of multiple recession defects was described in 2011 [51]. This approach entails thorough root instrumentation, including odontoplasty to remove portions of the root, which protrude beyond the gingival housing. Root prominence, as well as other site-specific charecteristics, have been demonstrated to be negatively correlated with periodontal root coverage [52].

The clinical case in Fig. 9.4 illustrates treatment of patient with multiple recession defects. In this case, following root preparation, a vertical vestibular incision was made in the midline frenum area. Sometimes, it is necessary to make multiple vestibular incisions to facilitate tunnel access. The vertical incision originates in the vestibular fornix and can extend to the base of the papillae. The incision should not approach closer than 5 mm away from the nearest gingival margin, in order to avoid tearing of the gingival margins. Subperiosteal tunnel was created to elevate the mucogingival complex away from the bone. The tunnel was extended coronally under attached gingiva and interdental papillae, to the extent possible, without making any surface incisions. The apical extent of the tunnel was beneath alveolar mucosa and released muscle attachments and elastic fibers, in an effort to achieve low-tension coronal positioning of the gingival margin. Laterally, the tunnel was

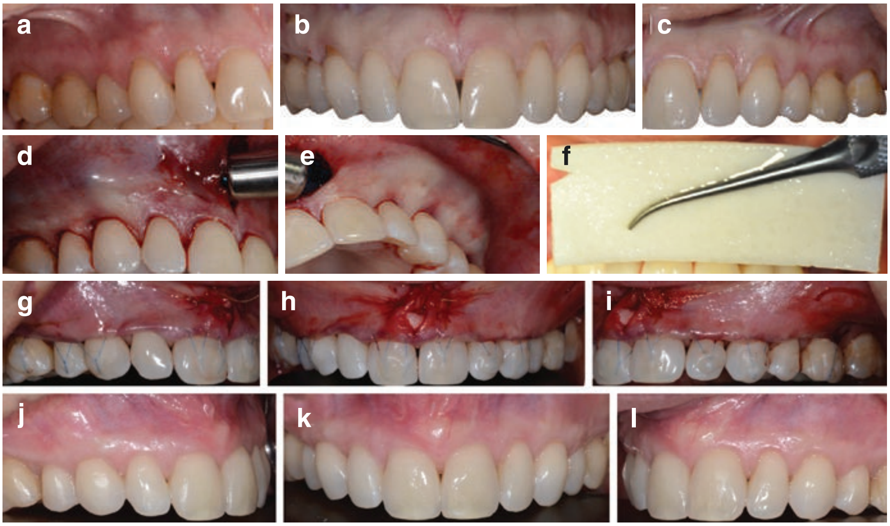

Fig. 9.4 Clinical case of a patient with combination of Miller Class II and Class III recession defects (**a**–**c**). Following root preparation, which included scaling and root planning with odontoplasty to reduce root prominence, an initial vertical vestibular incision was made in the midline, from which point, a subperiosteal tunnel was elevated elevated (**d**, **e**). The tunnel was elevated from the anterior region, extending to the first molar area. Acellular dermis allograft hydrated with platelet-derived growth factor was utilized in this case (**f**). Gingival margins were coronally positioned, and the gingival position was fixated, using 6.0 polypropylene sutures which were bonded in the coronal position with flowable composite (**g**–**i**). Once the gingival margins were fixated in coronal position, the allograft was inserted inside the tunnel. Postoperative results of the case after 1 year with complete root coverage (**j**–**l**)

extended to the adjacent posterior tooth (second molar), in order to facilitate coronal advancement, as well as to harmonize the gingival margin position and mucosal thickness with that of adjacent teeth. The gingival margins were coronally advanced at least 2 mm beyond the CEJ and fixated in that position, using sutures that were bonded to each tooth's midfacial coronal structure.

To treat teeth in the mandibular posterior region, the vestibular incisions are generally positioned anterior of the canine. Tunnel elevation in the mandibular posterior region is performed only in attached gingiva to the mucogingival junction in order to avoid injury to the mental neurovascular bundle. In addition, care must be taken to avoid occlusal interference with the additional of composite bondings. This may be particularly a problem in the mandibular posterior areas. In some cases, addition of composite to the central fossa of maxillary posterior teeth can open the bite to avoid interference with the bonded sutures. Once the sutures are removed after 3 weeks, the occlusal composites can also be removed.

The advantages of VISTA include avoidance of surface incisions near gingival margins or papillae, thus avoiding vascular disruption, esthetic complications, and accelerating healing. Moreover, there is better access to the apical areas for low-tension flap release. The main disadvantage includes potential scar formation in the location of vertical incision, though this is usually in an area, which is not readily visible.

9.7.5 Guided Tissue Regeneration (GTR)

Barrier membranes have been utilized in guided tissue regeneration for periodontal regeneration [53]. This concept has also been applied for the treatment of gingival recession. GTR has had variable results, primarily as a result of potential complications of membrane exposure and infection. SCTG has been shown to be more effective than GTR for root coverage [20].

9.7.6 Orthodontic Extrusion

Orthodontic tooth movement can modulate gingival position. In particular, orthodontic extrusion may be employed to coronally reposition gingival margin position [54]. This will require slow application of orthodontic forces at a rate of 1 mm or less per month.

In the case illustrated (Fig. 9.5), a patient with a history of advanced periodontitis, who completed periodontal therapy, had advanced gingival recession defects

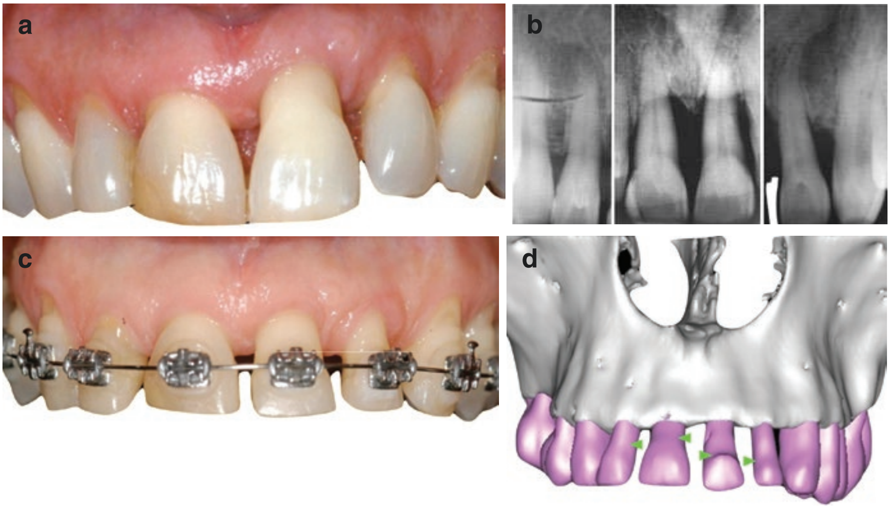

Fig. 9.5 Clinical (**a**) and radiographic (**b**) preoperative images of a patient with history of aggressive periodontitis with advanced gingival recession (Miller Class III) and marginal bone loss around maxillary incisors. Orthodontic-forced eruption was undertaken (**c**) to coronally advance and harmonize the gingival margins of the maxillary anterior teeth. Follow-up cone beam CT scan images with 3D rendering illustrate the harmonized alveolar bone margins with correction of the intraosseous defects (**d**). The positions of CEJ in the maxillary incisors (green arrow heads) have been altered in an effort to harmonize the alveolar bone crest

with associated severe vertical bone loss. Slow orthodontic extrusive forces were applied during approximately 9-month period. The patient was maintained in the final position without tooth movement for an additional 6 months. This leads to harmonization of gingival margin positions. The postoperative CBCT shows the discrepancies in the positions of right and left incisors created (green arrow heads).

9.8 Material Selection

An array of different materials is used for the treatment of gingival recession defects, including donor tissue (autologous, allogenic, and xenogenic), enamel matrix derivative (EMD), xenogenic collagen matrix (XCM), recombinant growth factors, autologous platelet concentrates, and living cell constructs (LCC).

9.8.1 Donor-Derived Tissue

Donor tissue has included skin graft [55], epithelialized palatal graft [14, 32], subepithelial connective tissue graft from palate or tuberosity [56], acellular dermal matrix (ADM) allograft [57], and xenogenic dermis [58]. In a comparative study to examine the composition of autologous mucosal grafts harvested from the lateral palate or the tuberosity, it has been shown that tuberosity grafts have more lamina propria and less submucosa [56]. The tuberosity has been demonstrated to have SCTG composition which is best suited for volume augmentation.

9.8.2 Xenogenic Collagen Matrix (XCM)

In an attempt to find viable alternatives to human donor-derived autogenous and allogenic graft material, XCM has been developed. There are both native [59] and cross-linked [60] XCM material, each of which has advantages and disadvantages. Native collagen may be applied to recipient sites, prepared by partial-thickness dissection and allowed to heal in an exposed manner, similar to FGG [61]. In that capacity, available data indicate favorable augmentation of both width and thickness of the zone of keratinized tissue [62–64]. Native porcine XCM has also been employed in conjunction with coronal advancement flap [65], as well as VISTA [66] with favorable outcomes. In a large multicenter randomized clinical trial, comparing CTG to native XCM, it was demonstrated that autogenous CTG had higher probability of achieving complete root coverage. However, the degree of root coverage was 1.7 ± 1.1 mm for CMX and 2.1 ± 1.0 mm for CTG. Therefore, the difference between the two groups was only 0.4 mm. Moreover, surgical time was 15.7 min shorter, the procedure was perceived to be lighter by patients, and the recovery time was 1.8 days shorter for XCM, compared to CTG.

Volume-stable cross-linked collagen matrix (VCMX) has been developed to increase mucosal thickness [60, 67]. VCMX is intended to be applied in submerged fashion. Results have demonstrated that the thickness gain with VCMX and CTG are equivalent [60, 67].

9.8.3 Enamel Matrix Derivative (EMD)

A large body of clinical and experimental evidence has demonstrated that enamel matrix proteins (EMPs) mediate periodontal regeneration. EMPs have been exploited therapeutically, through the use of EMD, which is clinically available as Emdogain. Treatment of gingival recession has been conducted with EMD plus CAF, not only to cover the roots but also to mediate periodontal regeneration [68]. There is available animal and human histologic evidence to demonstrate the re-formation of true periodontal regeneration with new bone, new PDF, new cementum, and functional fibers [68]. Randomized controlled studies have also demonstrated a mean root coverage of 84–94% [69]. Clinical trial data have demonstrated that, compared with CAF alone, CAF plus EMD yields increased root coverage, as well as keratinized gingiva width [69].

9.8.4 Autologous Platelets

Several generations of autologous platelet concentrate, along with various other components of blood (fibrin, leukocytes), have been utilized, using different protocols. These have included platelet-rich plasma (PRP), platelet-rich growth factor (PRGF), or platelet-rich fibrin (PRF). Each of these can also include leukocytes, e.g., leukocyte-platelet-rich fibrin (L-PRF).

There are mixed results, when L-PRF has been used in conjunction with CAF [70]. Comparison of L-PRF to SCTG by meta-analysis has demonstrated similar outcomes, namely, PD reduction (0.2, 0.3 mm, $p > 0.05$), CAL gain (0.2, 0.5 mm, $p > 0.05$), KTW (0.3, 0.4 mm, $p > 0.05$), and recession reduction (0.2, 0.3 mm, $p > 0.05$) [70].

9.8.5 Growth Factors

Recombinant human platelet-derived growth factor-BB (rhPDGF-BB) has been evaluated clinically and histologically for the treatment of gingival recession defects. Clinical results showed 90.8% root coverage with rhPDGF, compared with 98.6% root coverage with SCTG [71]. Histologic evidence demonstrated de novo alveolar bone, cellular cementum, and PDL regeneration mediated by rhPDGF-BB [72].

9.8.6 Living Cell Construct

Living cellular construct (LCC) is a combination of allogenic human keratinocytes, fibroblasts, human extracellular matrix proteins, and bovine collagen. This material has been used as a substitute for FGG for the treatment of gingival recession defects, where root coverage is not required. In a randomized controlled trial, comparing LCC to FGG [73], results have shown more keratinized gingiva generated by FGG (mean 4.5 mm) than LCC (mean 3.2 mm). LCC regenerated keratinized gingiva of 2 mm or more in 95.3% of the patients.

9.9 Conclusions

Untreated gingival recession is at higher risk of progression. Periodontal plastic surgery is an effective therapeutic strategy in achieving root coverage with improvement in periodontal clinical attachment level. Overall, no single therapy can be considered superior to all the others. The treatment strategy has to consider the following:

- Patient's esthetic demands
- Local site characteristics: gingival keratinized gingiva width, gingival thickness, root prominence, recession depth and width
- Restorative, orthodontic, and surgical plan
- Availability of donor tissue
- Patient's acceptance of graft material, i.e., donor tissue harvesting, allograft, xenograft, and animal-derived material
- Extent of treatment area: single vs multiple area vs full arch
- Clinician's experience, skills, and preference

Through systematic risk assessment, as well as consideration of above factors, the clinician and patient can select an appropriate treatment protocol and material.

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