



# Root Coverage With Emdogain/ AlloDerm: A New Way to Treat Gingival Recessions

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## Abstract

The recession of the gingival margin is becoming a more prominent condition in the oral situation of many patients and should be treated at its earliest detection. The multifactorial etiology, decision modality, and current trends in the treatment of gingival recession are discussed in this article. The surgical technique of choice depends on several factors, but among the different surgical protocols available, the clinician should select one that will minimize surgical trauma and achieve predictable esthetic results. All of the approaches described in this article can effectively treat deep and shallow Class I or II buccal recessions. Recently, as an alternative to autogenous gingival grafts in root coverage procedures,

enamel matrix derivative (Emdogain) and acellular dermal matrix allograft (AlloDerm) were utilized to correct these gingival defects, negating the morbidity and the requirement for a second palatal surgical procedure. Emdogain or AlloDerm materials used alone or in combination are a predictable treatment for root coverage, are relatively easy to perform (although they are technique sensitive), present low patient morbidity, offer a significant increase in the percentage of root coverage and amount of keratinized tissue, and should be part of the periodontal plastic surgery armamentarium.

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Gingival recession occurs when the location of the gingival margin is apical to the cemento-enamel junction (CEJ). Clinically, this results in exposed root surfaces, loss of marginal tissue, and loss of attachment.<sup>1</sup> Gingival recession is common in both populations with periodontal disease resulting from poor oral hygiene<sup>2</sup> and populations with high standards of oral hygiene.<sup>3</sup> The prevalence and extent of recession increase progressively with age.<sup>4</sup>

The most frequent etiologic factors associated with gingival recessions are tooth malposition,<sup>5</sup> factitious injury,<sup>6,7</sup> tooth mobility,<sup>8</sup> iatrogenic factors related to the location of the restoration margin and periodontal treatment procedures,<sup>9,10</sup> alveolar bone dehiscence,<sup>11</sup> traumatic tooth brushing/toothbrush abrasion,<sup>12</sup> and high muscle attachment with abnormal fraenum.<sup>13</sup>

An inadequate band of attached keratinized tissue has been associated with chronic inflammation and progressive recession in the presence of poor oral hygiene.<sup>14</sup> Orthodontic appliances, which can impede effective hygiene, can also lead to increased gingival recession in areas with minimal keratinized tissue and a thin labial cortical plate.<sup>3</sup>

The purpose of this article is to review the conventional mucogingival procedures and then describe via clinical cases the coverage of gingival recessions using recent bioengineering materials such as an enamel matrix derivative (EMD) (Emdogain, Straumann) and acellular dermal membrane (ADM) (AlloDerm, Biohorizons).

## Conventional procedures

A variety of surgical techniques have been developed to correct a lack of keratinized tissue and attain root coverage with high predictability in Miller Class I and II recession defects.<sup>15</sup> The root coverage techniques used by most clinicians include pedicle grafts (lateral sliding or double papillae) with or without connective tissue grafts, epithelialized autogenous (free gingival) grafts, connective tissue grafts, coronally advanced flaps (CAFs) alone, CAFs preceded by a free gingival graft, and CAFs with a simultaneous connective tissue graft. Each of these techniques results in varying degrees of success depending on the recession classification.<sup>16-24</sup>

These periodontal plastic surgery procedures for treatment of gingival recession have been improved by constant surgical and material modifications. Most of these modifications were developed to enhance blood supply to the graft, thereby increasing the success rates. Gingival grafts change the anatomy of the dental environment, and the soft tissue will be more resistant to future recession. A deeper vestibule with thicker, bound-down keratinized tissue increases the width of keratinized gingiva with satisfactory results. The intent of these procedures is principally to create a tissue barrier that is more resistant to further recession due to trauma and to treat the mucogingival root defects at the same time.

The indications for connective tissue grafting are as follows: inadequate donor site for a horizontal sliding flap, isolated wide gingival recession, multiple root exposures, and multiple root exposures in combination with minimal attached gingiva or in sites where ridge augmentation is desired.



If a dehiscence develops, gingival augmentation may be indicated in conjunction with tooth movement in order to halt progressive recession and facilitate plaque control and/or patient comfort. Masticatory mucosa may be needed around implants to stabilize and prevent peri-implant gingival recession.<sup>25</sup>

The advantage of free gingival and connective tissue grafts is that they are autografts. The subepithelial connective tissue graft covered by a CAF was considered the most predictable technique for achieving root coverage by some investigators. Connective tissue grafts show greater gain in root coverage and width of keratinized tissue compared to guided tissue regeneration (GTR) when used to reduce gingival recessions with concomitant improvements in attachment level. The connective tissue graft is statistically significantly more effective than GTR in treating recession.<sup>26</sup>

The palate is the usual source for connective tissue grafts, and there may be significant postoperative morbidity, particularly when large epithelialized gingival grafts are needed to treat generalized multiple gingival recession. Palatal anatomy may also limit the amount of autogenous tissue that can be harvested, thus decreasing the number of procedures that can be performed. This limitation of an adequate quantity of connective tissue can be further complicated by the presence of a small shallow or flat palate, which also impedes the clinician's ability to obtain an adequate amount of tissue to transplant. Furthermore, a patient may not desire to have additional tissue transplanted from the palate and decline to have both sides of the palate harvested simultaneously, due to the increased pain and morbidity associated with multiple transplant procedures.

Therefore, some disadvantages of connective tissue grafting will contraindicate this procedure, including the need for a second surgical procedure to harvest donor tissue, leading to patient discomfort; a limited amount of donor tissue for multiple recession sites; a longer surgical time; and a more technique-sensitive result.

## New bioengineering materials

The goal of periodontal plastic mucogingival procedures is to perform surgery as atraumatically as possible at the recipient and donor sites. Homeostasis, graft coverage with an overlying mucosal flap, and stability of the graft are consistent with the subepithelial connective tissue graft; however, as stated above, some limitations and drawbacks are present. Recently, as an alternative to autogenous gingival grafts in root coverage procedures, EMD and ADM allografts were utilized to correct these gingival defects, negating the requirement for a second palatal surgical procedure.<sup>27-34</sup>

### Enamel matrix derivative: Emdogain

#### Processing

EMD is a mixture of freeze-dried enamel matrix proteins harvested from the developing crown of a 6-month-old swine. EMD is used during periodontal therapy to promote regeneration. This material has been in use for more than 8 years, but its composition and mechanism of action are poorly understood. Nevertheless, clinical reports indicate that the material has positive effects on periodontal healing. Much of the research on



EMD has focused on its effects on periodontal ligament (PDL) cells. In vitro, EMD stimulates PDL cells to secrete platelet-derived factor (PDGF)-AB, transforming growth factor (TGF)- $\beta$ 1, and interleukin-6.<sup>35,36</sup>

### Advantages

EMD has been shown to possess the potential to stimulate and promote the formation of new connective tissue, bone, PDL, and cementum.<sup>15,37</sup> It was reported that EMD applied to instrumented root surfaces may remain active for up to 10 days and may influence enhancement of PDL cell proliferation, increase protein/collagen production, promote mineralization, and facilitate early healing of the soft tissue in the dentogingival region.<sup>28</sup> Cumulative evidence indicates that EMD can increase proliferation, migration, adhesion, and differentiation of the cells responsible for tissue healing in vivo.<sup>38</sup> Several studies have shown that EMD may not only enhance periodontal regeneration, it may also influence soft tissue healing via the migration of PDL cells and gingival fibroblasts to the root surface through gingival fibroblast stimulation.<sup>39</sup>

The use of EMD in the treatment of intra-bony defects and root coverage procedures was also demonstrated to produce successful bone regeneration and a gain of keratinized tissue after 4 months.<sup>40,41</sup> The application of EMD during collagen membrane GTR-based root coverage procedures is easy to perform and has low patient morbidity, but did not provide additional benefits to the final clinical outcome.<sup>42</sup> EMD application may be an alternative to connective tissue grafts to treat gingival recession.<sup>43</sup> It was also shown to improve the predictability of recession coverage in the treatment of Class I and II gingival recession from 62% to 89%.<sup>44</sup>

## Acellular dermal graft material: AlloDerm

### Processing

According to the manufacturer, the AlloDerm process de-cellularizes the allograft skin from screened donors to create an acellular biocompatible connective tissue matrix that consistently integrates following transplantation.

During the processing of AlloDerm, the epithelium is first removed from the donor tissue while the basement membrane is retained to promote faster re-epithelialization. Next, the cells are removed from the remaining tissue with a series of detergents to eliminate the chance for an antigenic response by the recipient. The product undergoes two key anti-viral steps: (1) de-cellularization, since viruses reside in human cells; and (2) the addition of an antiviral agent, which will inactivate HIV. The tissue is then freeze dried and packaged for immediate use. The graft material consists of a connective tissue surface that readily absorbs blood and a basement membrane surface that does not allow for blood absorption.

The resultant graft is an ADM with normal collagen bundling organization and an intact basement membrane complex. Since the AlloDerm process removes all cells, the components necessary for survival and transmission of viruses are removed. Furthermore, the removal of cells leaves no components to cause rejection or inflammation. Additionally, the graft is freeze dried. There has never been a reported case of HIV transmission from a transplant that has been freeze dried.<sup>43</sup>

The main advantages, disadvantages, and indications of the ADM allograft will now be presented.<sup>45</sup>





### Advantages

- No need for palatal autografts or other secondary surgical
- Unlimited material supply
- Ability to treat larger areas of multiple recession in one surgery
- Decreased surgical chair time
- Decreased patient morbidity
- Excellent esthetic results
- Increased patient motivation/acceptance

### Disadvantages

- Additional costs
- Learning curve associated with the handling of the material
- Technique-sensitive procedure
- Increased healing time

### Indications

- Root coverage on single and multiple gingival recessions
- Soft tissue flap extension over bone graft
- Amalgam tattoo correction
- Soft tissue defect repair
- Augmentation of a minimal band of keratinized tissue in shallow vestibule
- Increasing the zone of keratinized tissue around teeth and implants
- Ridge preservation/augmentation<sup>46</sup>

## Surgical protocol

EMD/ADM alone or combination offers an excellent alternative for patients who do not desire a second surgical site or have limited tissue available to harvest and transplant. The clinical cases presented in this article will illustrate the surgical use of these recent materials. All patients treated presented with very thin, transparent gingival margins. The exposed root surfaces were sensitive to hot

and cold air for young patients and/or were unesthetic for older patients.

### Preoperative protocol

Prior to the surgical procedure, all patients received scaling, root planing, and prophylaxis. If needed, oral hygiene instructions consisting of flossing and the roll technique using a soft toothbrush to address the related etiology of the gingival recession were also given. Full-mouth peri-apical and bitewing radiographs were taken to evaluate interproximal alveolar bone level to assist in gingival recession classification of teeth exhibiting recession defects. Vertical recession (height), horizontal recession (width), probing depth, and amount of keratinized tissue were measured. Only teeth with recession defects classified as Miller Class I or II were selected for treatment.<sup>47</sup> Prior to surgery, the patient rinsed for 60 seconds with a 0.12% chlorhexidine mouth rinse.

Rehydration of the acellular dermal graft material for a minimum of 10 minutes (with sterile saline combined with metronidazole solution) is essential. ADM should be oriented with the basement membrane side against the bone and teeth, while the connective tissue should face the overlying flap.

The surgical sites were anesthetized with 2% lidocaine HCl, 1:100,000 epinephrine. Teeth with gingival recession  $\geq 3$  mm as well as adjacent teeth with gingival recession  $\leq 2$  mm were included in the surgical procedure.

After peri-apical and intrapapillary anesthesia, bleeding points equivalent to the amount of buccal recession are marked in the adjacent interproximal papillae with a



probe at the location the interdental new papillae tip. Scalloped sulcular incisions are made with the new papillae tips formed from the existing papillae.

Two types of procedure have been used to treat this kind of patient: the flap elevation technique and the pouch-tunneling technique using EMD combined with ADM.

### Flap elevation

(Clinical case 1: Figs 1 to 10)

To increase the amount/thickness of keratinized tissue for restorative purposes (lamininate veneers) around teeth presenting multiple gingival recession, flap elevation was planned. The sulcular incision design using a round blade or a no. 15c blade enables an envelope full-thickness mucoperi-



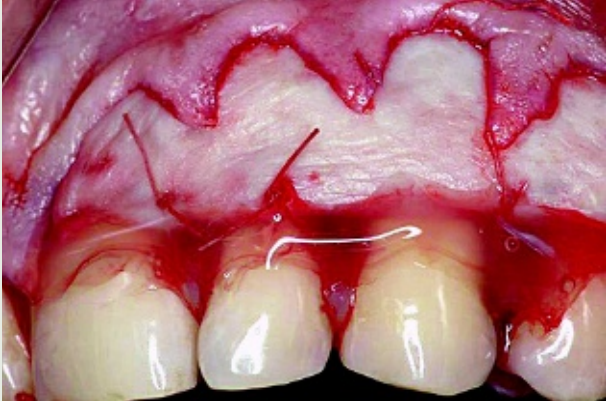
**Figs 1 and 2** Class I and II maxillary and mandibular multiple gingival recessions.



**Fig 3** Full-thickness elevation.



**Fig 4** Acid-gel preparation.



**Fig 5** ADM suturing and EMD-gel application over the root under the membrane.



**Fig 6** Coronally advanced flap with interrupted sling sutures.



**Figs 7 and 8** Three months after healing, total root coverage and increased keratinized gingiva are evident.



**Figs 9 and 10** Six months after healing with laminate veneers in place (Dr C. Raygot).







osteal flap reflection. This was extended 3 mm apical to the alveolar bone crest using a microperiosteal elevator, followed by split-thickness flap reflection.

The split-thickness flap dissection using a no. 15 blade was extended mesially, distally, and apically to facilitate adequate mobility and coronal positioning of the flap without tension. Releasing incisions were not performed to reduce the possibility of ADM exposure. This is an important factor since exposure could compromise the vascular supply to the ADM graft. The incision is extended to the nearest mesio/distal line angle of the adjacent nondefect tooth.

The root surfaces were planed thoroughly using curettes to remove contaminated cementum and then prepared using a fine diamond bur to flatten the prominent root surface as necessary. The exposed root surfaces were conditioned with pre-gel for 2 minutes to remove the smear layer. After acid application, the area was rinsed with saline solution.

The papillae were then de-epithelialized to ensure a good visualization of the connective tissue bed. The ADM graft was sized in the mouth. The graft was then removed from the mouth, adjusted to fit the area to completely cover the defect, and positioned at the CEJ. The superior and lateral borders of the graft are extended at least 3.0 mm beyond the alveolar defect margins. The ADM graft is placed with the basement membrane side against the bone and teeth, while the connective tissue side faces the overlying flaps.

Stretching the graft during suturing is advocated to counteract primary contraction and make the graft more receptive to vascularization. Graft stretching also helps prevent the development of dead spaces underneath the graft.

Since ADM is acellular, there are no blood vessels that could contain blood or dead spaces. Stretching the allograft provides better adaptation to the underlying periosteal surface and may also aid in the development of a new blood supply for the graft by opening microspaces in the graft to allow the ingrowths of blood vessels from the adjacent tissue.<sup>48</sup>

Correct suturing is critical for the success of this procedure, since it must be used to immobilize the graft and stabilize the underlying blood supply. Interrupted sutures between the margin of the graft and the base of the papillae lead to immobilization. Next, the ADM graft was further secured with sling sutures around the palatal side of the teeth and immobilized in the periosteum apically with an Ethicon 5/0 suture. This suture material is ideal because it is a monofilament with an extended resorption time of approximately 10 weeks. Following anchoring of the graft material, the flap is coronally advanced and sutured to cover the entire ADM graft using a double-sling suture technique with a palatal notch. The flap tension before suturing should be passive. Subsequently, EMD gel was applied with a syringe to the exposed root surface prior or after placing the ADM, or sometimes after suturing the flap to better visualize the surgical field.



## The tunneling-pouch technique (Clinical case 2: Figs 11 to 20)

The tunneling technique is used to treat simultaneous multiple Class I or II recession.<sup>49,50</sup> The sulcular incision design is developed using a round blade or a no. 15c blade. An envelope full-thickness mucoperiosteal flap reflection is extended 3 mm apical to the alveolar bone crest using a microperiosteal elevator, followed by split-thickness flap reflection. Split-thickness flap dissection, using a no. 15 blade or the mi-

croperiosteal elevator and staying in close contact with the contour of the bone periosteum to prevent cutting the muscles fibers, was extended mesially, distally, and apically to facilitate adequate mobility and coronal positioning of the flap without tension. This partial dissection is carefully performed to create a deep pouch beyond the mucogingival junction, being careful not to perforate the alveolar mucosa while keeping the tip of the interproximal papillae attached to the teeth below the proximal contact point.



**Fig 11** Class I and II multiple gingival recessions.



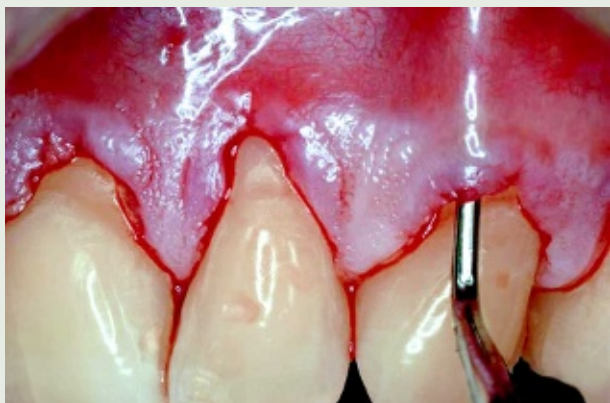
**Fig 12** Sulcular incision performed with an ophthalmic blade.



**Fig 13** Mini-full thickness flap elevation performed with a micro-elevator.



**Fig 14** Papillae elevation using the Orban knife without cutting the peak of the papillae.



**Fig 15** After partial dissection, the vertical depth of the pouch is assessed with a periodontal probe.



**Fig 16** Continuity of the tunneling is explored with the probe.



**Fig 17** ADM is cut into 2 pieces before rehydration.



**Fig 18** Insertion of the ADM in the tunnel using a suture needle.



**Fig 19** Coronally advanced flap with suspended sling sutures.



**Fig 20** Full root coverage after 3 months of healing.





The root surfaces were planed thoroughly using curettes to remove contaminated cementum and then prepared using a fine diamond bur to flatten the prominent root surface as necessary. The rehydrated ADM graft should be oriented with the basement membrane side against the bone and teeth, while the connective tissue should face the overlying flap. ADM is delicately inserted below the papillae inside the pouch using a 4-0 suture on one extremity and then stabilized with the CAF using a 5-0 vicryl sutures.

## Postoperative protocol

Immediately following surgery, an ice pack was applied intermittently at 15-minute intervals for the first 2 hours at the surgical site. All patients were advised to discontinue mechanical oral hygiene measures for 4 weeks following surgery to minimize trauma to the surgical sites. A cold liquid diet was recommended for the first 24 hours.

Several medications are recommended and prescribed to the patient:

- Chlorhexidine gluconate gel (0.2%) applied 6 times a day for 4 weeks. This regimen should be continued until routine oral hygiene procedures can be resumed at approximately 1 month.
- Systemic antibiotic (amoxicillin 500 mg, 3 times a day for 7 days) to prevent bacterial plaque from colonizing the graft material and enhance optimal healing.
- Ibuprofen 400 mg 3 times a day to control postsurgical pain.
- Methyl prednisolone tablets (20 mg for 3 days) to minimize undesirable postsurgical problems and reduce postoperative swelling.

The healing progressed uneventfully with the exception of some postoperative oedema in the days immediately following surgery. It is important to prevent as much swelling as possible because clinical experience has shown that oedema can disrupt graft stability and cause the sutures to pull through the papillae, thus resulting in apical flap displacement.

The patient is seen weekly for postoperative visits to evaluate healing and plaque control. Sutures are not removed until the 1-month postoperative visit. The patient is instructed to resume gentle mechanical tooth brushing on the treated sites using a soft brush with the roll technique after 4 weeks. Professional plaque control, consisting of debridement and oral hygiene instruction, was performed weekly during the first 4 weeks, and scaling was performed at the 3-month and 6-month recalls.

Complete root coverage in both surgical techniques was achieved in addition to increasing the thickness of the marginal tissue. Following 6 weeks to 3 months of healing, the gingiva showed a healthy appearance. The gingival margins appeared thicker and more resistant to trauma. Sulcular probing depths were 2 mm or less. In approximately 6 months, the tissue will mature to a smooth contour.

## Discussion

The objective of mucogingival plastic surgery is successful coverage of exposed root surfaces, along with good esthetics and function. In a 2-year prospective study, tooth-brushing habits were shown to be of greater importance than increased gingival thickness for long-term maintenance of





the surgically established soft tissue margin. Modifications in oral hygiene instruction, consisting of the roll technique using a soft toothbrush, meticulous oral hygiene maintenance, and flossing, may help to improve long-term stability.<sup>26</sup> Many surgical techniques have been evaluated in an attempt to achieve more effective and predictable root recession coverage while minimizing surgical complications.

### Coronally advanced flap

Zucchelli and Sanctis<sup>51</sup> evaluated the effectiveness of a new surgical approach to CAFs in the treatment of multiple Miller Class I and II recession defects in patients with esthetic demands. At the 1-year examination, on average, 97% of root surfaces were covered with soft tissue, whereas 88% showed complete root coverage. Without vertical releasing incisions, blood supply to the flap was adequate—a factor deemed critical to the success of the surgery and avoidance of an unesthetic white scar.

Comparisons between the study groups revealed no statistically significant differences in terms of clinical attachment gain, probing depth reduction, and increase in keratinized tissue from baseline to 6 months. Root coverage was 79% for the test group and 63.9% for the control group. The mean gain of keratinized tissue was 0.7 mm for the ADM group and 0.2 mm for the CAF group.

Cigarette smoking negatively impacted the clinical outcomes, specifically the residual recession, percent of root coverage, and frequency of complete root coverage.<sup>52</sup>

The modified technique is more suitable for root coverage procedures with ADM since it had statistically significantly better clinical results compared to the traditional technique with a connective tissue graft.<sup>43</sup>

It can be concluded that both techniques can provide significant root coverage in Class I and II gingival recessions (76% for the ADM group and 71% for the CAF group); however, greater keratinized tissue thickness can be expected with ADM.<sup>53</sup> Treatments with a CAF plus an ADM allograft significantly increased gingival thickness compared with a CAF alone. Recession defect coverage was significantly improved with the use of ADM.<sup>54</sup>

### Subepithelial connective tissue graft

Connective tissue grafts are currently considered the gold standard for root coverage since they are highly predictable procedures for treating recession defects with an average of 65% to 98% root coverage. However, root coverage with connective tissue grafts appears to be negatively associated with cigarette smoking. Smokers should consider smoking cessation or reducing the use of cigarettes for optimal results with connective tissue grafts.<sup>55</sup> A common concern of patients is that connective tissue grafts require an additional surgical site and produce added morbidity. Harvesting a palatal or other intraoral donor site causes additional discomfort to the patient and increases chair time for the surgeon. Although connective tissue grafts and ADM grafts have a slightly different histologic appearance, both can be used successfully to cover denuded roots with similar attachments and no adverse healing.<sup>34</sup>



Recession defects may be covered using ADM or connective tissue grafts with no practical differences. However, connective tissue grafts result in a significantly greater gain of keratinized gingiva.<sup>56</sup> Semilunar CAFs and subepithelial connective tissue grafts were effective in providing root coverage in Class I and II gingival recession defects where the patient presented with at least 2 mm of keratinized gingiva prior to root coverage; however, subepithelial connective tissue grafts resulted in thicker gingival tissue.<sup>57</sup> The use of acellular dermal graft material in mucogingival surgery can minimize or eliminate both of these problems.

Obtaining predicable and esthetic root coverage is important, and similar results were obtained with connective tissue grafting and ADM. However, in long-term cases where multiple defects were treated with an acellular dermal matrix, the mean root coverage (70.8%) was greater than the mean root coverage in long-term cases where a single defect was treated with a connective tissue graft (50.0%). It seems that ADM may be better indicated for multiple recession defects.<sup>30</sup>

These results indicate that the extended flap technique in the treatment of localized gingival recessions with an ADM graft exhibit statistically significant superior clinical performance compared with the conventional connective tissue technique.

These results indicate that root coverage via subpedicle ADM allografts or subepithelial connective tissue autografts is a very predictable procedure that is stable for 2 years postoperatively. However, subepithelial connective tissue autografts resulted in significant increases in defect coverage, keratinized gingival gain, attachment gain, and residual probing depth.<sup>45</sup>

### Enamel matrix derivative

A CAF alone or with EMD is an effective procedure to cover localized gingival recessions. The addition of EMD significantly improves the amount of root coverage.<sup>44</sup>

Both connective tissue grafts and EMD proved clinically successful. Connective tissue grafts showed a higher percentage of root coverage and increased amounts of keratinized gingiva. EMD is a valuable, long-term treatment alternative to achieve root coverage together with an increase in height of keratinized gingiva.<sup>58</sup>

At concentrations of  $< 50 \mu\text{g/mL}$ , EMD results in significant stimulation of microvascular endothelial cells proliferation, suggesting a possible mechanism for periodontal wound healing. It is likely that EMD stimulates angiogenesis directly by stimulating endothelial cells and indirectly by stimulating the production of angiogenic factors via PDL cells. It also likely that EMD enhances the communication between microvascular endothelial cells and PDL cells during angiogenesis associated with healing.<sup>59</sup>

### Acellular dermal matrix

ADM grafting has become increasingly popular as a substitute for connective donor tissue in plastic periodontal surgeries in order to achieve more esthetic and long-lasting results for gingival recession in the esthetic zone. Recently, ADM grafting was effectively used as a substitute for autogenous gingival grafts in root coverage procedures.<sup>53</sup>

This material is available in unlimited supply without creating a second surgical site and can be purchased in small or large pieces to cover limited or large areas



of buccal recession in one surgery.<sup>60</sup> The main disadvantage is that the material is an allograft, requiring donated tissue from a human source and creating more expenses for the patient.

ADM was reported to increase gingival thickness and keratinized tissue thickness compared to CAF alone, particularly in cases that involved recessions on multiple teeth. Gingival attachment to the root surface was comparable for connective tissue grafts and ADM grafts, demonstrating a long junctional epithelium and connective tissue adhesion, with the underlying alveolar bone essentially unaffected. The grafted ADM appeared to be well incorporated with new fibroblasts, vascular elements, and collagen while retaining its elastic fibers throughout. From 6-month histologic observations, it was apparent that equivalent attachment to the root surface was present. An increase in marginal tissue thickness was also present, equivalent to a palatal graft.<sup>54</sup>

In general, the survival capability of grafts at the receptor site represents a great challenge for root-coverage surgical procedures. This is even more challenging when dealing with ADM grafts in the esthetic zone, which is a nonvital graft dependent on host cell infiltration and blood vessel invasion. The use of ADM prevented the need for a second surgical site for donor material and the possible postoperative complications. It also enhanced patient comfort and satisfaction. It has demonstrated excellent functional and esthetic results.<sup>61</sup>

This new root-coverage technique emphasizes the need for a close blood supply evaluation and better tissue manipulation when dealing with ADM. The flaps should be broad enough at the base to include major gingival vessels. The devel-

opment of the extended flap technique for root coverage with ADM grafts shown in this study was based on this principle. In fact, the displacement on the adjacent teeth provides more blood vessels, more nutrients, and a better source of cells. Further, it allows easier tissue manipulation, especially in obtaining a tensionless CAF to completely cover the allograft. This effort is particularly important because the ADM graft has the ability to revascularize only when in direct contact with vital tissues.<sup>43</sup>

The results revealed a statistically significant improvement in clinical performance with the ADM approach. Previous studies showed that ADM grafts increased marginal tissue thickness histologically as well as clinically. It was suggested that a thin gingival biotype and delicate marginal tissues could be factors in increasing the risk for gingival recession. Therefore, an increase in gingival thickness resulting from the ADM graft may prevent further recession in patients with a thin periodontal biotype.

### EMD and ADM (Clinical case 3: Figs 21–29)

EMD or ADM treatments for root coverage are relatively easy to perform and present low patient morbidity and a significant increase in the percentage of root coverage and keratinized tissue. Cueva et al<sup>33</sup> demonstrated that EMD increased the percentage of root coverage and width of keratinized tissue.

A recent study<sup>62</sup> demonstrated that ADM and ADM plus EMD significantly improved the clinical variables in terms of horizontal recession, vertical recession, probing attachment level, root surface area, percentage of root surface coverage, and amount



of keratinized tissue. EMD used in conjunction with ADM resulted in a statistically significant increase in keratinized tissue. This technique has proved very effective for the treatment of multiple gingival recessions. The results of the present study compared favorably with previous studies reporting an increase in keratinized tissue, predictable root coverage, and clinical attachment gain following ADM grafting.<sup>62</sup>

Most of the failures occurred in heavy smokers. A review of the patients' health questionnaires revealed a 100% correlation between failure to obtain root coverage and heavy smoking. After this correlation was made, heavy smokers were requested to refrain from smoking during the initial 2-week phase. Miller Class I and II recession defects healed with almost complete defect coverage, regardless of whether ADM or ADM plus EMD was used, whereas more predictable clinical root coverage was observed when ADM plus EMD was used. No significant differences in probing attachment level or percentage of root surface coverage were observed when sites treated with ADM plus EMD were compared to sites treated with ADM alone.<sup>62</sup>

The last clinical case presented in this article (clinical case 3: Figs 21 to 29) is in accordance with the conclusions of the above study: (1) If there is no need to increase the amount of keratinized gingiva ( $\geq 3$  mm), either EMD or ADM could be used to cover the single or multiple gingival recessions; and (2) If, on the contrary, there is less than 3 mm of keratinized marginal gingiva around the recession, or if there is a particular objective to increase the quality and quantity of soft tissue, then it is recommended to use EMD combined with ADM.



**Fig 21** Class I and II multiple gingival recessions with cervical abrasion.



**Fig 22** The amount of keratinized gingiva on the left canine is  $> 3$  mm with a gingival cleft on the first premolar.

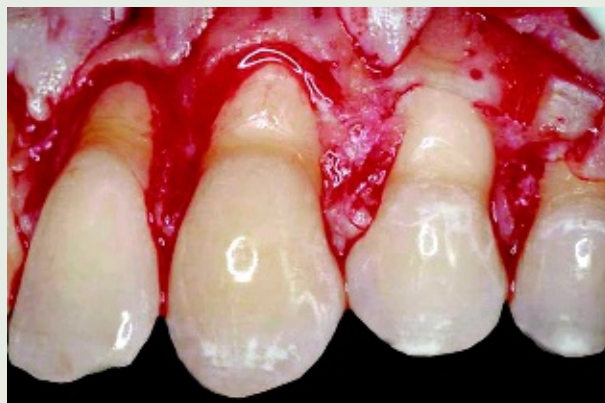


**Fig 23** Full/partial flap dissection and elevation.





**Fig 24** Acid-gel application on the root surface



**Fig 25** Clean root surface after rinsing the gel.



**Fig 26** ADM suture on the lateral incisor and premolar.



**Fig 27** EMD-gel application on the canine only.



**Fig 28** Free-tension coronally advanced flap with sling sutures.



**Fig 29** After 6 months of healing, total coverage of the gingival recessions is evident, with the same amount of keratinized gingiva on the canine and adjacent teeth.



## Conclusions

EMD and ADM grafts have become increasingly popular as substitutes for donor connective tissue in single and multiple gingival recession and augmentation procedures because they eliminate the aforementioned disadvantages of autogenous graft materials. One limitation of autogenous grafts is the limited supply of donor connective tissue. Multiple sites often need several surgical procedures, which is not well accepted by patients.

EMD obtained from embryonic pork enamel may enhance microvascular cell effects on the tissue-specific cells required to support the regeneration process. This new finding helps explain the role of EMD in periodontal healing.<sup>59</sup>

Alloderm is obtained from human donor skin tissue in a process that removes cell components while preserving the remaining bioactive components and extracellular matrix, which is subsequently freeze dried. Therefore, the allograft exhibits undamaged collagen and elastin matrices that function as a scaffold to allow ingrowth by host tissues. Due to its nonvital structure, it depends on cells and blood vessels from the recipient site to achieve reorganization.

EMD/ADM alone or in combination should be used as an alternative to autogenous free or connective gingival grafts to cover Class I and II gingival recessions and increase the width/thickness of keratinized gingiva around natural teeth or implants, as well as for ridge augmentations. This procedure does not require a second surgical site. Postoperative recovery is routine, with minimal pain and regular swelling reported by patients. An excellent esthetic match can be achieved with the adjacent gingival tissue. ADM has no col-

or, and therefore develops appearance from the cells of adjacent tissues.<sup>63</sup>

EMD and ADM provide statistically significant improvements in the adjacent teeth. The use of EMD alone or in conjunction with ADM also demonstrates the superiority of the procedure in the treatment of localized gingival recessions by avoiding the postoperative morbidity associated with harvesting palatal connective tissue. The unlimited supply of EMD and ADM allows for extended elevated flaps to achieve multiple site root coverage.<sup>64</sup> The proposed technique of root coverage with an ADM graft could be a good alternative to soft tissue grafts and should now be part of the periodontal plastic surgery armamentarium.<sup>65</sup>

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