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Therapeutic Outcomes for Gingival Recession Defects in the Esthetic Zone: A Systematic Review

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Abstract

Background: The aim of this paper is to review the major quantitative and qualitative therapeutic outcomes for gingival recession defects in the esthetic zone.

Methods: PubMed and MEDLINE were searched for entries up to April, 2012. For the assessment of quantitative parameters, criteria for considering studies for this assessment was based on the most current systemic review by Chambrone published in April, 2012. For the assessment of qualitative parameters, only studies that evaluated the soft tissue esthetic outcome of recession areas treated with root coverage procedures were included.

Findings: Quantitative measurements of root coverage, such as percentage of root coverage and the percentage of gingival augmentation, provide objective assessment and the advantage of reliability. However, parameters that account for the global esthetic evaluation are not evaluated by the quantitative measurements. On the other hand, qualitative evaluation, such as scarring, texture, volume, color, gingival contour, and the location of mucogingival junction, is subjective and per se imperfect. It is limited to esthetic appearance and cannot replace the clinical quantitative assessment. More explicit criteria are required to improve the reliability of scales for esthetic assessment.

Conclusions: The final esthetic goal of a root coverage procedure should include the achievement of complete root coverage and the complete soft tissue integration.

Keywords: Gingival recession; Systematic review; Esthetic; Treatment outcomes

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Introduction

Gingival recession is defined as the location of the gingival margin being apical to the cemeto-enamel junction (CEJ) [1], and it is regularly linked to the deterioration of dental esthetics. The prevalence of ≥ 1 mm recession in persons 30 years and older was 58%, and the extent of ≥ 1 mm recession averaged 22.3% teeth per person [2]. According to Miller's classification [3], Miller Class I signifies marginal tissue recession not extending to the mucogingival junction (MGJ) and no loss of interdental bone or soft tissue. Miller Class II indicates marginal tissue recession extends to or beyond the MGJ and no loss of interdental bone or soft tissue. Miller Class III denotes marginal tissue recession extends to or beyond the MGJ and loss of interdental bone or soft tissue is apical to the CEJ but coronal to the marginal extent of the marginal tissue recession. Miller Class IV designates marginal tissue recession extends to or beyond the MGJ and loss of interdental bone extends to a level apical to the extent of the marginal tissue recession.

Mucogingival therapy is a general term used to describe periodontal treatment involving procedures to correct defects in morphology, position, and/or amount of soft tissue and underlying bone [1]. A more specific term, mucogingival surgery, was defined as surgical procedures designed to correct defects in the morphology, position, or enhance the dental gingival junction, since defects in the morphology of the gingival and alveolar mucosa can accelerate the course of periodontal disease, or interfere with the successful outcome of periodontal treatment [1]. In 1993, Miller [4] proposed the term periodontal plastic surgery (PPS), considering that mucogingival surgery had moved beyond the traditional treatment of problems associated with

the amount of gingiva and recession type defects to also include the correction of ridge form and soft tissue esthetics. Accordingly, periodontal plastic surgery was defined as surgical procedures to prevent or correct anatomical, developmental, traumatical, or plaque disease-induced defects of the gingiva, alveolar mucosa, or bone [5]. In recent years, some systemic reviews were published focusing on the effect of periodontal plastic surgery procedures on the treatment of localized recessions [6-10]. Different surgical techniques and flap designs, including free gingival graft (FGG), subepithelial connective tissue graft (SCTG), acellular dermal matrix (ADM), enamel matrix derivative (EMD), guided tissue regeneration with resorbable (GTRrs) or non-resorbable membrane (GTRnrs), coronally positioned flap (CPF) and laterally positioned flap (LPF), had been described in the aforementioned articles and used in an attempt to correct gingival recessions.

Independent of the modality of surgical procedure used to obtain soft tissue root coverage, shallow residual probing depths, gain in clinical attachment, and reduction in gingival recession are the common characteristics of treatment outcome. Although the major indication for performing root coverage procedures is esthetic/cosmetic demands, few studies have included qualitative assessments of esthetics as an end-point of success [11]. As an alternative, the common outcome variables used are the amount of root coverage achieved, expressed in percentage of the initial depth of the recession defect, and the proportion of treated sites showing complete root coverage [12]. However, the evaluation of the quantitative parameters following surgery may be restrictive and not adequate to assess the overall results. As a matter of fact, esthetic failure may occur in cases with partial root coverage, poor color match of gingival tissue, malalignment of the MGJ, and formation of keloid like texture. The ideal technique for root coverage should produce a result not only achieving complete root coverage, shallow probing depth, and adequate band of keratinized tissue, but also attaining acceptable color match to surrounding tissue, esthetic tissue contour, minimal pain and no tooth sensitivity [13].

Patient-based outcome measures refer to questionnaires or related forms of assessment that patients have completed by themselves or, when necessary, by others on their behalf. Patient-based outcome measures are obtained based on patients' experiences and concerns in relation to their health status, health-related quality of life and the results of treatments received [14]. Unlike traditional measures, which rely on clinical or laboratory procedures to measure the effectiveness of a therapy, patient-based measures focus on outcomes such as quality of life that are important to the patient. Chambrone et al. [15] further defined evidence-based PPS as the systemic assessment of clinically relevant scientific evidence designed to explore the esthetic and functional effects of treatment on gingival recession defects, alveolar mucosa and bone, based on clinician's knowledge and patient's centered outcomes. A critical evaluation showed that current literatures adopted similar focused questions and reported significant improvements in recession depth and in clinical attachment level (CAL), with or without keratinized tissue (KT) gain, irrespective of surgical technique; however, there are insufficient data with respect to patient-centered outcome.

The treatment of gingival recession defects is indicated for esthetic reasons, to reduce root sensitivity, to remove muscle pull, and to create or augment KT [5]. Since the main indication for root coverage procedures is esthetic/cosmetic demand, the tooth location and tooth type are emphasized in this article. The esthetic zone is usually defined as the dentition spanning maxillary or mandibular first bicuspid [16]. To achieve a successful esthetic result and good patient satisfaction, studies involving in the esthetic zone are evaluated. Therefore, the aim of this study is to review the major quantitative and qualitative therapeutic outcomes for gingival recession defects in the esthetic zone.

Materials and Methods

Assessment of quantitative parameters

Criteria for considering studies for this assessment are modified based on the most recent systemic review by Chambrone et al. [12]. Only randomized controlled clinical trials of at least 6 moths duration were included in this study.

The types of participants included (1) A clinical diagnosis of localized gingival recession-type defect; (2) Recession areas selected for treatment classified as Miller Class I or Class II [3] that were surgically treated by means of PPS procedures; (3) Availability of individual patient data (baseline and final measurements) for inclusion in the statistic model to integrate the information of patient characteristics into the analysis of the efficacy of treatment procedures; (4) Individuals greater than 18 years old; (5) Treatment teeth located in the esthetic zone, including incisors, canines, and premolars in the maxillary arch.

The interventions of interest were free gingival grafts (FGG), laterally positioned flap (LPF), coronally positioned flap (CPF), subepithelial connective tissue grafts (SCTG), acellular dermal matrix grafts (ADM), guided tissue regeneration (GTR), enamel matrix derivatives (EMD) or other biomaterials, and combinations. Types of outcome measures included the percentage of sites with complete root coverage (CRC), mean root coverage (RC), change in height (RH) and width (RW) of gingival recession, change in width (WKT) and thickness (TKT) of keratinized tissue, gain in clinical attachment level (CAL), and reduction in probing depth (PD).

Assessment of qualitative parameters: Only studies of at least 6 months duration were included for the assessment of qualitative therapeutic outcomes. The type of participants included Miller Class I or Class II recession defects treated for root coverage. Individuals must be greater than 18 years old for the assessment of qualitative therapeutic outcomes. The interventions of interest were FGG, LPF, CPF, SCTG, ADM, GTR, EMD or other biomaterials, and combinations.

Types of outcome measures included the soft tissue esthetics describing gingival color, gingival contour, gingival texture, gingival consistency, gingival contiguity/blending, keloid/scar formation, or mucogingival junction (MGJ) alignment. However, root sensitivity, patients' pain/discomfort, the occurrence of adverse effects, the post-operative complications, patient's satisfaction and preference are not included.

Search methods for identification of studies: Search methods for identification of studies included electronic and hand searching. The electronic searching was performed using PubMed and MEDLINE from 1950 to October 2010 by the keywords recession and root coverage. Papers were limited to those articles published in English. Journal of Periodontology and Journal of Clinical Periodontology were identified as important to this review and

were hand searched. Reference lists of any potential studies were also examined in an attempt to identify any other studies.

Results

Assessment of quantitative parameters

SCTG: The results of Chambrone's [8] review show that SCTG provided significant gain in RC, CAL, and WKT. Overall comparisons allow us to consider it as the "gold standard" procedure for the treatment of recession-type defects.

CPF+SCTG vs CPF: The outcome of gingival recession therapy using CPF alone or in conjunction with SCTG was compared by da Silva et al. [17]. Eleven subjects with bilateral Class I recession (≥ 3 mm in depth), involving 13 upper 1st premolars, 8 upper canines, and 1 upper 2nd premolar, were recruited **(Table 1)**. Clinical parameters, including RH, WKT, TKT, PD, and CAL, were assessed at baseline and 6 months after surgery. TKT was assessed at 2 different positions: at the middle of the apico-coronal width of KT and 2 mm apical to the MGJ. The average root coverage was 68.8% for CPF group and 75.3% for CPF+SCTG group. At 6 months postoperatively, both surgical approaches had significant improvement in RH, PD, and CAL. Mean RC was 75% in CPF+SCTG group and 69% in CPF alone group; however, there were no statistically significant differences between the two groups. It should be noted that CPF+SCTG showed statistically significant increase in WKT and TKT compared to CPF alone group **(Table 2)**. Therefore, when an increase in gingival dimensions (WKT and TKT) is a preferred outcome, then the combined technique (CPF+SCTG) should be used.

Bittencourt et al. [18] compared the long-term outcomes (30 months) of SCTG and semilunar CPF (SCPF) in the treatment of gingival recession. Seventeen patients with bilateral Miller Class I (≤ 4 mm) gingival recession defects in maxillary canines and premolars were recruited **(Table 1)**. At the 30-month examination, the mean percentage of RC obtained was 89.25% for SCPF and 96.82% for SCTG. SCTG maintained a statistically significant increase in TKT, but there were no significant differences between these two groups with regard to RH, RW, WKT, PD, and CAL **(Table 2)**.

CPF+SCTG with partial vs full thickness flap elevation: Mazzocco et al. [19] studied the efficacies of CPF combined with an SCTG using partial or full thickness flap reflection in the treatment of gingival recession. Twenty patients with Miller Class I or II defects (≤ 4 mm) had CPF + SCTG, with a full-thickness flap reflection in the test group and a partial-thickness flap reflection in the control group. A total of 52 teeth were treated **(Table 1)**. At 6 months, the mean RC was 97% and 95% in the test group and control group, respectively. CPC was accomplished in 80% and 63% for the test and control group, respectively. RH and WKT were significantly improved compared to the baseline. No significant differences were found between these two groups for the parameters in RH, WKT, and PD **(Table 2)**. Therefore, the elevation of a full or partial thickness flap did not appear to influence the amount of WKT or the percentage of RC achieved after surgery.

CTG using double-pedicle papilla flap with macro- vs micro-surgery: Burkhardt and Lang [20] evaluated the degree of vascularization of CTG covered by a double-pedicle papilla flap. Ten non-smoking subjects presented with bilateral Miller Class I or II gingival recession on maxillary canine **(Table 1)**. The defects were randomly assigned to either a micro (test)- or macro (control) -surgical approach. A set of microsurgical instrument was used under a surgical microscope for microsurgically treated recessions. The percentage of RC in the test and control sites was statistically significant difference and both remained stable during the first year at 98% and 90%, respectively **(Table 2)**. Consequently, a microsurgical approach substantially improved the percentages of RC as compared to that of a conventional macroscopic approach.

EMD

CPF+EMD vs CPF alone: Modica et al. [21] assessed the effect of EMD with CPF to enhance the clinical results of RC at a 6-month follow-up. Twelve non-smoking patients with 14 pairs of Miller Class I or II bilateral gingival recession were selected **(Table 1)**. The treatment consisted of a CPF procedure with (test) or without (control) EMD. Root surfaces were conditioned with EDTA 24% for a maximum of 2 minutes. The mean RC was 91.2% and 80.9% for the test and control group, respectively. Both procedures produced significant changes in RH and CAL, with no differences between these two groups. No changes of PD and WKT were found **(Table 2)**. It was concluded that EMD did not significantly improve the clinical outcomes of gingival recession treated by means of CPF.

Similar outcomes were also reported by Del Pizzoet al. [22], who evaluated the ability of EMD to improve RC using a CPF during a 2-year follow-up. Fifteen non-smoking patients with bilateral Miller Class I or II gingival recessions were selected **(Table 1)**. Each recession was randomly assigned to test (CPF+EMD) or control (CPF alone) group. Root surface was conditioned with 24% EDTA for 2 minutes. At 24 months, a mean RC of 90.67% and 86.67% was achieved for the test and control group, respectively. The changes in RH, RW, WKT, and CAL were significant within group from baseline to 24 months for both control and test groups, although there was no significant difference between these two groups **(Table 2)**. Hence, the authors suggested that the use of EMD to CPF has no clinical benefits in regard to RC.

CPF+EMD vs CPF+EMD+CTG: Berlucchi et al. [23] described 2 different surgical techniques for RC using EMD in 14 patients. Thirteen pairs of gingival recessions were classified as Miller Class I or II, and the depths were greater than 2 mm **(Table 1)**. Patients were randomly assigned to either the CPF+EMD group or the CPF+EMD+CTG group. Root surface was conditioned with 24% EDTA for 2 minutes. From baseline to 6 months, RH was significantly reduced and CAL was significantly gained in both groups. However, no statistically significant difference in RC was found between these two groups (93.97% for CPF+EMD and 93.59% for CPF+EMD+CTG group). WKT was increased for both groups, but statistically significantly more for CPF+EMD+CTG **(Table 2)**.

GTR

CPF+ GTRrs vs CPF alone: Banihashemrad et al. [24] assessed the effect of a GTRrs in combination with CPF as compared to CPF alone in the treatment of Miller Class I or II gingival recessions. Seven nonsmokers took part in the study, each providing either 2 or 4 recessions of 3 to 6 mm. A split mouth design was used. RH, RW, WKT, PD and CAL were measured in both group at baseline and 6 months after the surgery. Tooth location and tooth type

Table 1 Characteristics of included studies for quantitative/objective esthetic evaluation.

ABM: anorganic bone mineral, ADM: acellular dermal matrix graft, BL: baseline, BS: bone substitute, C: control, CM: xenogeneic collagen matrix graft, CPF: coronally positioned flap, DPF: double papilla flap, F: human gingival fibroblasts, FTF: full thickness flap, GR: gingival recession, GTRrs: guided tissue regeneration with resorbable membrane, m: month, NS: nonsmoker, PTF: partial thickness flap, RC: root coverage, RH: recession height, RW: recession width, SCPF: semilunar coronally positioned flap, SCTG: subepithelial connective tissue graft, T: test, TKT: thickness of the keratinized tissue.* Not described in the text but showed in figures; †One patient had mandibular teeth treated, all other defects were in the maxillary arch.

Source	# of pt/sites	f/u period (month)	Miller and RH	Tooth location/type	Age (mean)	Smoking status	Surgical intervention
Banihashemrad et al. [24]	7/11 pairs Split mouth	6	I/II ≥3 mm	Maxillary canines/premolars and mandibular canines*	35-65 (45)	NS	CPF CPF+ GTRrs
Barros et al. [36]	14/16 pairs Split mouth	12	I/II ≥3 mm	Mandibular canines and premolars*	22-46 (33)	NS	CPF+ADM CPF+ ADM(mod)
Berlucchi et al. [23]	14/13 pairs	6	I/II ≥2 mm	Centrals/laterals/canines/ premolars/1st molars	20-45 (30.6)	NS	CPF+EMD CPF+CTG+EMD
Bittencourt et al. [18]	17/17 pairs Split mouth	30	I ≤ 4 mm	Maxillary canines/premolars	21-52 (33.5)	NS	SCPF SCTG
Burkhardt and Lang [20]	10/8 pairs Split mouth	12	I/II>3 mm	Maxillary canines	32-44	NS	CTG+DPF (macro) CTG+DPF (micro)
Cardaropoli et al. [25]	16/10 pairs	6	I/II ≥2 mm	Maxillary canines/premolars	18-54 (33.06)	NS	CPF CPF+GTRrs+BS
Silva et al. [17]	11/11 pairs Split mouth	6	I ≥ 3 mm	Maxillary canines/premolars	18-43 (29.2)	NS	CPF CPF+SCTG
Queiroz et al. [33]	13/13 pairs Split mouth	24	I ≥ 3 mm	Maxillary canines/premolars	(32.8)	NS	CPF CPF+ADM
Del Pizzo et al. [22]	15/15 pairs Split mouth	24	I/II ≥ 3 mm	Maxillary and mandibular canines/1st premolars	18-56 (39.46)	NS	CPF CPF+EMD
Haghighati et al. [34]	16/16 pairs Split mouth	6	I/II ≥ 2 mm	Incisors/canines/premolars	>18 y/o	NS	CPF+ADM CPF+SCTG
Henderson et al. [35]	10/10 pairs Split mouth	12	I/II ≥ 3 mm	Maxillary laterals/canines/1st premolars†	24-68 (42.2)	NS	CPF+ADM CPF+ADM(mod)
Jepsen et al. [31]	15/15 pairs Split mouth	12	I/II>2 mm	Max. Lateral/canine/1st premolar/1st molar and mand. canine/premolar	20-62 (40)	N/A	GTRnrs+CPF CTG (envelope)
Lins et al. [30]	10/10 pairs Split mouth	6	I/II>2 mm	Maxillary canines/1st premolars	25-55 (38.2)	NS	CPF GTRnrs+CPF
Matarasso et al. [28]	20/20	12	I/II ≥ 3 mm	Maxillary centrals/canines/1st premolars and mandibular canines	18-42 (31)	N/A	GTRrs+CPF GTRrs+DPF
Mazzocco et al. [19]	20/52 Parallel	6	I/II ≤ 4 mm	Maxillary or mandibular incosors/ canines/premolars	21-57	NS	CTG+CPF (PTF) CTG+CPF (FTF)
McGuire and Scheyer [38]	25/25 pairs Split mouth	12	≥ 3 mm	Maxillary canines*, Molars were excluded	18-70 (43.7)	NS	CPF+SCTG CPF+CM
Modica et al. [21]	12/14 pairs Split mouth	6	I/II	Maxillary canines/premolars/1st molar and mandibular canines	20-50 (33.8)	NS	CPF CPF+EMD
Nazareth and Cury [39]	15/15 pairs Split mouth	6	I ≥ 2 mm	Maxillary canines/premolars	22-47	NS	CPF CPF+ABM/P-15
Roccuzzo et al. [29]	12/12 pairs Split mouth	6	I/II ≥ 4 mm	Maxillary canines	21-31 (25.4)	NS	GTRnrs+CPF GTRrs+CPF
Rossetti et al. [27]	12/12 pairs Split mouth	18	I/II ≥ 3 mm	Maxillary canines/premolars	25-60 (39)	NS	CPF+DFDBA+GTRrs CPF+ SCTG
Tatakis and Trombelli [26]	12/12 pairs Split mouth	6	I/II ≥ 2 mm	Maxillary canines/premolars and mandibular canines	22-48 (38)	NS	CPF+GTRrs CPF+CTG
Woodyard et al. [32]	24 Parallel	6	I/II ≥ 3 mm	Maxillary canine/premolar and mandibular incisor/canine/premolar	18-90 (34.6)	NS	CPF+ADM CPF

were not described in the text, but 2 cases (one on mandibular canine and the other on maxillary canine and 1st premolar) with pre- and post-surgery pictures were shown **(Table 1)**. There were statistically significant improvements in RH, RW and CAL for both groups. The root coverage was 67.9% in CPF+GTRrs group and 57.4% in CPF group. The difference between these two groups was statistically significant **(Table 2)**.

CPF+GTRrs+bone substitute vs CPF alone: Cardaropoli and Cardaropoli [25] compared the efficacy of two surgical techniques (CPF alone as the control group vs CPF in combination with an

absorbable collagen membrane and a demineralized xenograft as the test group) in the treatment of gingival recession. Sixteen nonsmokers presented with at least one Miller Class I or II recession ≥ 2 mm on a maxillary canine or premolar **(Table 1)**. The percentage of root coverage was 93.33% and 92.49% for the test and control group, respectively. 70% of the test sites and 60% of the control sites achieved 100% RC. Both treatments resulted in a statistically significant reduction in recession and gain in CAL within group. However, there was no statistically significant difference between these two groups. The increase in WKT from baseline to 6 months was slightly greater for the test group than that of the control group, but with no significance difference. The test group experienced a statistically significant increased in TKT from baseline to 6-month; the difference between these two groups was statistically significant and in favor of the test group **(Table 2)**.

CPF+GTRrs vs CPF+CTG: Tatakis and Trombelli [26] evaluated the effect of a GTR procedure with a poly (lactic acid)-based bioabsorbable membrane in comparison to CTG in the treatment of recession defects. Tetracycline HCl solution (10 mg/ml in saline) was applied on root surfaces for 4 minutes. Twelve non-smoking patients were treated. Each patient contributed one pair of Miller Class I or II gingival recessions equal to or greater than 2 mm **(Table 1)**. At 6 months, a significant improvement in RH, RW, and CAL was observed. Average RC was 96% for CTG and 81% for GTR group. The prevalence of CRC was 83% for CTG and 58% for GTR. Although differences between CTG and GTR in mean RC and prevalence of CRC consistently favored CTG, the differences in measurements were not statistically significant **(Table 2)**.

CPF+GTRrs+DFDBA vs CPF+SCTG: Rosetti et al. [27] compared the GTR procedure using a bioabsorbable collagen membrane associated with DFDBA to a SCTG (both under a CPF) after 18 months post-surgery. Twelve nonsmokers with a minimum of 3 mm gingival recession (Miller Class I or II) of upper canines or premolars participated in this study **(Table 1)**. Roots surfaces were conditioned with tetracycline hydrochloride (125 mg/ml) for 3 minutes. Both procedures produced statistically significant differences for RH, WKT, and PD at 18 months after therapy when compared to pre-operative parameters. SCTG was statistically significantly better than GTR for RH and WKT; however, PD was significant better for GTR than SCTG. When percentage of RC was analyzed, the difference between these two groups was not statistically significant (SCTG=95.6%; GTR=84.2%) **(Table 2)**.

GTRrs using CPF vs double papilla flap: Matarasso et al. [28] evaluated the results of GTR (polylactic acid membranes) using double papilla flap (test group) vs CPF (control group) techniques on gingival recession. Twenty patients with 20 pairs of Miller Class I or II recession (3 mm deep) were recruited in this study **(Table 1)**. Periodontal parameters including RH, WKT, PD and CAL were recorded. A mean root coverage of 73.9% and 62.5% was found in the test and control group, respectively. The results obtained at a 1-year follow-up were comparable between the test and control groups for RH, PD and CAL, although the test group obtained a statistically significant larger amount of WKT as compared to that of control group **(Table 2)**.

CPF+GTRrs vs CPF+GTRnrs: Roccuzzo et al. [29] treated twelve patients with either a bioresorbable matrix barrier (test) or a non-resorbable expanded polytetrafluoroethylene membrane (control). Bilateral gingival recessions ≥ 4 mm (Miller Class I or II) on maxillary canines were treated **(Table 1)**. RH, WKT, PD and CAL were measured at baseline and at 6 months post-surgically. Both procedures resulted in significant RC (82.4% for test and 83.2% for control) and CAL gain. Data analysis did not demonstrate any significant difference between the two procedures for any of the variables included **(Table 2)**.

CPF+GTRnrs vs CPF alone: Lins et al. [30] evaluated the outcome of a GTR procedure using a titanium-reinforced expanded polytetrafluoroethylene (tr-ePTFE) barrier and to compare it to the outcome of a CPF procedure. Exposed root surfaces were conditioned with 50 mg/ml tetracycline solution for 3 minutes. Ten non-smoking patients had 20 Miller Class I or II ginigval recession defects (≥ 2 mm) on 10 matched pairs of contralateral teeth were recruited **(Table 1)**. Clinical measurements including RH, WKT, PD and CAL were taken immediately before surgery and at 6 months following surgery. The changes in RH and CAL at 6 months post-surgery were statistically significant when compared to pre-surgical measurements in both groups. The mean RC was 45% in GTR group and 60% in CPF group. The amount of RC obtained with CPF was greater than that observed in GTR **(Table 2)**, although GTR resulted in significantly greater alveolar crest level gain.

CPF+GTRnrs vs CTG: Jepsen et al. [31] compared the use of titanium reinforced ePTFE membrane to CTG employing the envelope technique in the treatment of recession defects. Fifteen patients with 15 pairs of Miller Class I or II gingival recession were recruited **(Table 1)**. Root surfaces were conditioned with tetracycline solution (100 mg/ml) for 3 minutes. Twelve months after therapy, both treatment modalities showed significant reduction in RH, and gain in both WKT and CAL. The mean RC was 87.1% for GTRnrs and 86.9% for CTG **(Table 2)**.

ADM

CPF+ADM vs CPF alone: Woodyard et al. [32] compared CPF plus ADM to CPF alone to determine the ADM effect on gingival thickness and percentage of RC. Twenty-four subjects each with one Miller Class I or II recession defect ≥ 3 mm were recruited **(Table 1)**. Root surfaces were conditioned with tetracycline solution (100 mg/ml) for about 4 minutes. The mean RC was 99% for ADM and 67% for CPF and the difference was statistically significant. TKT was increased by 0.4 mm and WKT increased by 0.8 mm for ADM, whereas CPF remained essentially unchanged **(Table 2)**. A similar outcome was found by de Queiroz Cortes et al. [33] in which thirteen nonsmokers with bilateral Miller Class I (≥ 3 mm) gingival recessions on upper canines or premolars were treated using CPF with or without ADM **(Table 1)**. The clinical measurements in RH, RW, WKT, TKT, PD, and CAL were taken before and 6, 12, and 24 months after surgery. After 24 months, both treatments produced significant changes in RH, WKT, PD, and CAL within group. However, for RW in ADM and TKT in CPF, no statistically significant difference was observed between baseline and 24 months. The mean RC was 68.04% for ADM and 55.98 for CPF. There were no statistically significant differences in RH, RW, PD, and CAL between these two groups. However, significantly greater TKT and WKT were observed in ADM group **(Table 2)**.

CPF+ADM vs CPF+CTG: Haghighati et al. [34] investigated the effectiveness of SCTG and ADM in RC procedures 6 months after surgery. Participants were 16 nonsmokers with 16 pairs of Miller

Table 2 Outcomes of included studies for quantitative/objective esthetic evaluation.

*Within-groups comparison: treatment outcome is significantly different from baseline; †Between-groups comparison: treatment outcome is significantly different between the two groups.

Source	Surgical intervention	Mean								
		BL RH	% of RC	% of CRC	RH reduction	RW reduction	WKT gain	TKT gain	PD reduction	AL gain
Banihashemrad et al. [24]	CPF	3.64	57.4	18	2.0*†	1.91*†	-0.18		0.36*	2.36*†
	CPF+ GTRrs	4.46	67.9	18	3.0*†	2.64*†	0.36		0.73	3.73*†
Barros et al. [36]	CPF+ADM	3.4	62.3	6	2.2*†		1.0*		0.3	1.6*
	CPF+ ADM(mod)	3.9	82.5	19	3.2*†		1.3*		0.6*	1.9*
Berlucchi et al. [23]	CPF+EMD	3.31	93.97	77	3.08*		0.69*†		0.15	3.23*
	CPF+CTG+EMD	3.46	93.59	85	3.23*		1.38*†		0.15	3.39*
Bittencourt et al. [18]	SCPF	2.20	89.25	59	1.92*	3.04*	0.86*	0.07†	0.02	1.94*
	SCTG	2.15	96.83	88	2.05*	3.15*	1.14*	0.33*†	0.15	1.94*
Burkhardt and Lang [20]	CTG+DPF (macro)	4.06	89.9	25	?		?		?	?
	CTG+DPF (micro)	4.04	98.0	63						
Cardaropoli and Cardaropoli [25]	CPF	2.7	92.49	60	2.5*		0.55	0.17†	0.05	?
	CPF+GTRrs+BS	2.5	93.33	70	2.35*		0.80	0.88*†	0.10	
Silva et al. [17]	CPF	3.98	68.8	9	2.73*		-0.21†	0.01†	0.42*	2.30*
	CPF+SCTG	4.20	75.3	18	3.16*		0.55*†	0.44*†	0.55*	2.53*
Queiroz et al. [33]	CPF	3.58	55.98	8	1.96*	1.08*	0.31*†	0.13†	1.42*	1.54*
	CPF+ADM	3.46	68.04	8	2.31*	1.04	0.62*†	0.51*†	1.42*	1.96*
Del Pizzo et al. [22]	CPF	4.13	86.67	60	3.53*	2.67*	0.47*		0	3.53*
	CPF+EMD	4.07	90.67	73	3.67*	3.06*	1.00*		0.07	3.67*
Haghighati et al. [34]	CPF+SCTG	3.37	69.05	31	2.31	?	?		?	?
	CPF+ADM	2.93	85.42	69	2.52					
Henderson et al. [35]	CPF+ADM	3.7	95	80	3.55*		0.8*		0	3.65*
	CPF+ ADM(mod)	4.2	95	70	3.95*		0.8*		0.1	4.15*
Jepsen et al. [31]	GTRnrs+CPF	3.6	87.1	47	3.1*		1.5*		0.1	3.0*
	CTG (envelope)	3.6	86.9	47	3.1*		2.5*		0.1	3.1*
Lins et al. [30]	CPF	3.3	60	10	1.9*†		0.6		0	2.0*
	GTRnrs+CPF	3.4	45	10	1.5*†		1.1		0	1.5*
Matarasso et al. [28]	GTRrs+CPF	4.0	62.5	10	2.5*		0.9		0.3	2.8*
	GTRrs+DPF	4.6	73.9	10	3.4*		2.0*		0.3	3.1*
Mazzocco et al. [19]	CTG+CPF (partial)	1.77	95	63	1.68*		0.49*		0.32	
	CTG+CPF (full)	2.36	97	80	2.27*		0.46*		0.22	
McGuire and Scheyer [38]	CPF+SCTG	3.20	99.3	88	3.17†	4.22†	1.09		0.24	2.85
	CPF+CM	3.14	88.5	74	2.78†	3.22†	1.11		0.50	2.26
Modica et al. [21]	CPF	3.50	80.9	50	2.71*		0.07		0.07	2.79*
	CPF+EMD	3.71	91.2	64	3.36*		0.22		0.21	3.57*
Nazareth et al. [39]	CPF	2.67	90	73	2.4*		0.07	0†	0.27	2.13*
	T: CPF+ABM/P-15	2.60	85.56	67	2.2*		0.07	0.03*†	0.27	1.93*
Roccuzzo et al. [29]	GTRnrs+CPF	4.75	83.2	42	4.00*		0		0.42	4.42*
	GTRrs+CPF	4.75	82.4	42	3.92*		-0.17		0.42	4.33*
Rossetti et al. [27]	CPF +DFDBA+GTRrs	3.75	84.2	25	2.63*†		1.50*†		1.41*†	
	CPF+ SCTG	4.16	95.6	67	3.96*†		3.54*†		0.84*†	
Tatakis and Trombelli [26]	CPF+GTRrs	2.5	81	58	2.0*	3.1*	0.1		0.0	2.0*
	CPF+CTG	2.5	96	83	2.4*	3.8*	0.7		0.3	2.2*
Woodyard et al. [32]	CPF+ADM	3.46	99	92	3.42*†		0.81	0.4*†	0.25	3.67*†
	CPF	3.27	67	33	2.19*†		0.33	0.03†	0.5	2.69*†

Class I or II recession defects with at least 2 mm gingival recession **(Table 1)**. With regard to the amount of mean RC, no significant difference was found between ADM (85.4%) and SCTG (69.05%) groups. However, the percentage of CRC was significantly greater in ADM group (75%, vs 31% in SCTG group) **(Table 2)**. They concluded that ADM seems to be a good substitute for SCTG to treat shallow to moderate gingival recessions.

CPF+ADM vs CPF+ADM (mod): Henderson et al. [35] treated

ten patients, each with 2 Miller Class I or II recession defects ≥ 3 mm, using a CPF plus ADM **(Table 1)**. Test sites received treatment with the basement membrane side of ADM against the tooth, while control sites received the same material with the connective tissue side against the tooth. Smokers were excluded. Root surfaces were conditioned with tetracycline solution (100 mg/ml) for 4 minutes. In regard to RH, WKT, and CAL, there were statistically significant differences between the initial and 12-month examinations for both control and test groups. There were no statistically significant differences between the control and test groups **(Table 2)**. Therefore, the authors concluded that the orientation of ADM does not affect the treatment outcome for any of the parameters tested. Barros et al. [36] compared the 1-year clinical outcome of a new surgical approach (test) with the outcome of a conventional procedure [37] (control) for the treatment of localized gingival recessions using ADM. In the control group, the releasing incisions were placed on the proximal surfaces of the involved teeth, while in the test group, the two releasing incisions were displaced to the mesial and distal line angles of the adjacent teeth, providing a broader flap to favor ADM incorporation. Fourteen non-smoking patients with 16 pairs of Miller Class I or II defects (≥ 3 mm) were included. Tooth location and tooth type were not described in the text, but 2 cases with pre- and post-surgery pictures were shown **(Table 1)**. Exposed root surfaces were conditioned with a 24% EDTA gel for 2 minutes. The percentages of RC were 82.5% for test and 62.3% for control groups. Significant clinical changes in RH, WKT, and CAL for both surgical techniques were achieved. Comparisons between these two groups revealed statistically significant greater reduction in RH favoring the two releasing incisions technique **(Table 2)**.

Other biomaterials

CPF+CM (xenogeneic collagen matrix graft) vs CPF+SCTG: McGuire and Scheyer [38] designed a split-mouth study for the treatment of dehiscence-type recession defects (≥ 3 mm); one defect received CPF+CM (test site), whereas the other defect received a CPF+SCTG (control site). Twenty-five subjects were followed up to 1 year after the surgery. Patients with a history of smoking within the previous 6 months and molar teeth were excluded. Tooth location and tooth type were not described in the article, but pictures illustrating pre- and post-surgery comparison were shown **(Table 1)**. The exposed root surfaces were conditioned with 24% EDTA for 2 minutes. Changes in RH and RW from baseline to 6 months were statistically significant between test and control. At 1 year, the average percentage of RC was 88.5% and 99.3% for the test and control group, respectively **(Table 2)**.

CPF+ anorganic bone mineral/peptide-15 (ABM/P-15) vs CPF alone: Nazareth and Cury [39] recruited 15 subjects with bilateral Miller Class I gingival recessions (≥ 2 mm) involving maxillary canine or premolar teeth **(Table 1)**. The bilateral defects were randomly assigned to the test group (CPF+ABM/P-15) or to the control group (CPF alone). The reduction in gingival recession and gain in CAL were significant within group for both treatments, with no differences between groups. The percentage of RC was 85.56% and 90.00% in test and control group, respectively. A significant increase in TKT was observed in the test group with no clinically significant **(Table 2)**. It was concluded that CPF associated with ABM/P-15 provided no beneficial in RC as compared to CPF alone.

Assessment of qualitative parameters

Ordinal scale: Bouchard et al. [40] evaluated clinical and esthetical effects of SCTG to cover gingival recessions using a traditional procedure compared to the use of a modified technique. In one group, the epithelial collar of the graft was preserved and left exposed (CTG), while in the other group, the epithelial collar of the graft was removed and totally immersed under the flap which was coronally positioned (CTG+CPF). Thirty patients each with one site of gingival recession were recruited **(Table 3)**. Impressions and photographs of the recessions were taken pre-operatively and 6 months after surgery by 2 independent examiners who were blinded to the given treatment. The evaluation of the esthetic results was scored as good, moderate, or poor **(Table 4)**. They reported that better esthetic results were found in the CTG+CPF group as compared to those of CTG group. None of the defects had a "poor" result **(Table 5)**.

Rosetti et al. [27] compared SCTG and GTR with a collagen membrane and DFDBA in patients with bilateral gingival recessions on upper canines or premolars **(Table 3)**. Clinical photographs taken at baseline and after 18 months for esthetic evaluation were given to 5 examiners who were not participating in the study. All examiners were dentists with more than 5 years of experience in cosmetic dentistry. The esthetic scoring evaluated root coverage, gingival anatomy, contour, and color after surgery **(Table 4)**. The scoring system was as follows: good=esthetics after treatment were better than before; regular=esthetics did not improve after treatment; and poor=esthetics after treatment were worse than before. The esthetic analysis demonstrated improvement in both groups without significant differences between groups. Most of the cases were rated as "good" (80% for SCTG treated and 81.7% for GTR-treated recessions), and "poor" esthetic result was not given by any of the examiners **(Table 5)**. It was concluded that satisfactory esthetic results can be achieved by both techniques.

Wang et al. [41] compared 2 techniques, SCTG versus GTR using a collagen membrane, for Miller Class I or II recession defects (≥ 3 mm) in 16 patients. Tooth location and tooth type were not described in the text, but 2 cases with pre- and post-surgery pictures were shown **(Table 3)**. Photographs were taken at each post-operative visit to evaluate color match, contour, consistency, contiguity or blending, and degree of keloid formation at the 6-month post-surgical interval. An independent periodontist was asked to rate the color match as excellent, good, adequate, or unsatisfactory. Contour was judged based on the presence or absence of a scalloped and knife-edged gingival margin. Consistency was described as firm or spongy. Contiguity was evaluated based on the confluence between the graft and recipient flap and was rated with yes or no. Keloid was scored as absent or present. Patient satisfaction on esthetics after RC was recorded **(Table 4)**. For periodontist preference, 15 out of 16 GTR sites had excellent color match, while 11 out of 16 SCTG sites reported the same (5 SCTG had good). Good contour was noted in 15 GTR sites versus 13 SCTG sites. Tissue showed firm consistency in all sites treated by either technique. As compared to 16 GTR sites, 14 SCTG sites were rated as having an acceptable blend. Keloid formation was noted in only one SCTG site. In addition, Patient satisfaction on esthetics was similar for both groups **(Table 5)**.

Aichelmann-Reidy et al. [42] compared ADM and CTG for the

Table 3 Characteristics of included studies for qualitative/subjective esthetic evaluation.

ABM: anorganic bone mineral, ADM: acellular dermal matrix graft, BL: baseline, C: control, CM: xenogeneic collagen matrix graft, CPF: coronally positioned flap, DPF: double papilla flap, F: human gingival fibroblasts, GR: gingival recession, GTRrs: guided tissue regeneration with resorbable membrane, m: month, NS: nonsmoker, P: private practice based, PCG: Autogenous platelet concentration grafts + collagen sponge, RC: root coverage, RH: recession height, RM: root modification, RW: recession width, SCPF: semilunar coronally positioned flap, SCTG: subepithelial connective tissue graft, T: test, TKT: thickness of the keratinized tissue, U: university based.

*Not described in the text but showed in figures; †One patient had mandibular teeth treated all other defects were in the maxillary arch.

Source	# of pt/site	Tooth location/type	Surgical intervention	f/u period (month)
Bouchard et al. [40]	30/30	Maxillary and mandibular incisors/canines/ premolars	CTG CPF+CTG	6
Rosetti et al. [27]	12/12 pairs	Maxillary canines/premolars	CPF +DFDBA+GTRrs CPF+ SCTG	18
Wang et al. [41]	16/16 pairs	Maxillary molars and mandibular canines/ premolars*	CPF+GTRrs CPF+SCTG	6
Aichelmann-Reidy et al. [42]	22/22 pairs	Maxillary laterals and mandibular laterals/ canines/premolars*	CPF+ADM CPF+SCTG	6
Zucchelli et al. [43]	15/15 pairs	Maxillary incisors/canines/premolars	CPF+CTG CPF+CTG(mod)	12
Cheung and Griffin [44]	18/54	Maxillary canines and premolars*	CPF+PCG CPF+CTG	8
Kerner et al. [45]	133/281	N/A	Pedicle soft tissue grafts, Non-submerged grafts, Submerged grafts, Envelope technique	6-130 (median 11.72)
Bittencourt et al. [18]	17/17 pairs	Maxillary canines and premolars	SCPF SCTG	30
Cairo et al. [53]	31/31	Maxillary central/laterals/canines/1st premolars and mandibular central/canines/premolars	CPF, FGG, CTG, DPF, or combination	6
Jhaveri et al. [55]	10/10 pairs	Maxillary canines and premolars	CPF+ADM+F CPF+SCTG	6
Cairo et al. [54]	41/41	Maxillary laterals and canines*	CPF, FGG, CTG, DPF, EMD, or combination	6
McGuire and Scheyer [38]	25/25 pairs	Maxillary canines*, Molars were excluded	C: CPF+SCTG T: CPF+CM	12
McGuire et al. [51]	9/9 pairs	Maxillary† incisors/canines/premolars	C: CPF+CTG T: CPF+EMD	10 yrs

treatment of gingival recession. Twenty-two patients with 2 similar Miller Class I or II gingival recession of ≥ 2 mm were treated. The location of the treated tooth was not described in the text, but pictures on maxillary laterals and mandibular laterals/ canines/premolars were shown **(Table 3)**. Independent clinicians were asked to rate the color match as excellent (3 points), good (2 points), adequate (1 point), or unsatisfactory (0 point). Contour was judged based on the presence (2 points) or absence (0 points) of a scalloped, knife edged gingival margin. Consistency was described as firm (1 point) or spongy (0 point). Contiguity was evaluated based on the number of perceptible surfaces at the confluence of the graft and recipient flap. Each distinguishable surface was assigned a negative value for a cumulative value of negative 3 points if all 3 adjoining surfaces were prominent. Absence of keloid was assigned 1 point. In addition, a research assistant, independent of the clinical examiner, recorded patient satisfaction on the esthetics (color match, overall satisfaction, and amount of root coverage) **(Table 4)**. Color slides were taken up to 6 months. Global assessments by clinicians and patients suggested a more esthetic clinical result with ADM. Clinician evaluation showed differences in favor of ADM for color match, contour and contiguity, and essentially similar scores between the 2 groups for consistency and lack of keloid formation **(Table 5)**.

Zucchelli et al. [43] recruited 15 patients with bilateral Miller Class I or II recession defects. Only teeth from upper right 2nd premolar to upper left 2nd premolar were included in the study **(Table 3)**. All defects were treated with a bilaminar surgical technique (CTG covered by a CPF); the differences between test and control surgical approaches resided in the size, thickness and positioning of the CTG. In the test sites, the apico-coronal dimension of the graft was equal to the depth of the bone dehiscence, the thickness was less than 1 mm, and the position was apical to the CEJ at a distance equal to the height of keratinized tissue originally present apical to the recession defect. In the control tooth, the apico-coronal length of the graft was 3 mm greater than the depth of the bone dehiscence, the thickness of the graft was greater than 1 mm, and the position was at the level of the CEJ. Patients were asked to express their opinion about the appearance of the treated teeth by selecting one of the following choices: bad, sufficient, good, and optimum. In the case of difference in the esthetic opinion between test and control teeth, patients were asked to indicate the reason(s) for this difference by selecting one or more of the following choices: difference in tooth length, in color blending, or in gingival thickness **(Table 4)**. The results obtained at the 12-month follow-up visit showed that patients were more satisfied with the appearance at test sites and less satisfied at control sites with poor color blending and excessive thickness of the gingival tissue **(Table 5)**.

Table 4 Methods of included studies for qualitative/subjective esthetic evaluation.

ABM: anorganic bone mineral, ADM: acellular dermal matrix graft, BL: baseline, C: control, CM: xenogeneic collagen matrix graft, CPF: coronally positioned flap, DPF: double papilla flap, F: human gingival fibroblasts, GR: gingival recession, GTRrs: guided tissue regeneration with resorbable membrane, m: month, NS: nonsmoker, P: private practice based, RC: root coverage, RH: recession height, RM: root modification, RW: recession width, SCPF: semilunar coronally positioned flap, SCTG: subepithelial connective tissue graft, T: test, TKT: thickness of the keratinized tissue, U: university based.

Source	Evaluation method	Evaluator	Evaluation parameters	Scale
Bouchard et al. [40]	Casts Photographs	2 examiners	N/A	Three-point ordinal scale: Good/Moderate/poor
Rosetti et al. [27]	Photographs	5 dentists (cosmetic dentistry)	Root coverage Gingival anatomy Contour Color	Three-point ordinal scale: Good: improved Regular: same Poor: worse
Wang et al. [41]	Photographs	1 periodontist	Color match	Excellent/Good/Adequate/Unsatisfactory
			Contour	Poor/Good/Adequate/Unsatisfactory
			Consistency	Firm/Spongy
			Contiguity or blending	Yes /No
			Keloid formation	Present/Absent
		16 Patients	Color match Overall satisfaction Amount of root coverage	Three-point ordinal scale: Excellent/Good/Fair
Aichelmann-Reidy et al. [42]	Photographs	Clinicians	Color match	Excellent/Good/Adequate/Unsatisfactory
			Contour	Present/Absent
			Consistency	Firm/Spongy
			Contiguity or blending	Yes /No
			Keloid formation	Present/Absent
		22 patients	Color match Overall satisfaction Amount of root coverage	Four-point ordinal scale: Excellent/Good/Fair/Poor
Zucchelli et al. [43]	N/A	15 patients	Tooth length Color blending Gingival thickness	Four-point ordinal scale: Bad/Sufficient/Good/Optimum
Cheung and Griffin [44]	Photographs	3 periodontists	Color match Tissue texture Tissue contour	Four-point ordinal scale: 1-4 1: favorable;4: less favorable
Kerner et al. [45]	Photographs	2 periodontists 1 nurse	Overall esthetic appearance Color match Texture match Volume match Lack of hypertrophic scar Gingival contour	Before-after panel scoring system Five-point ordinal scale: Poor/Fair/Good/Very good/Excellent
Bittencourt et al. [18]	N/A	17 patients	N/A	Four-point ordinal scale: Bad/Sufficient/Good/Excellent
Cairo et al. [53]	Clinical	1 periodontist	Root coverage esthetic score	
			Level of gingival margin	0=Failure of root coverage 3=Partial root coverage 6=Complete root coverage
			Marginal tissue contour	0=Irregular, not following CEJ 1=Scalloped, following CEJ
			Soft tissue texture	0=Presence 1=Absence of scar/keloid formation
			MGJ alignment	0=Not aligned with adjacent teeth 1=Aligned with adjacent teeth
			Gingival color	0=Varies from adjacent teeth 1=integrates with adjacent teeth
Jhaveri et al. [55]	Clinical	1 dentist	Root coverage esthetic score	
Cairo et al. [54]	photographs	11 periodontists	Root coverage esthetic score	

McGuire and Scheyer [38]	Clinical	1 examiner	Color Texture	Equal or not equal to surrounding tissue
McGuire et al. [51]	Clinical	1 examiner	Comparing to surrounding tissues	
			Color	More red/less red/equally red
			Texture	More firm/less firm/equally firm
			Contour	More contour/less

Table 5 Outcomes of included studies for qualitative/subjective esthetic evaluation.

Source	Surgical intervention		Patient			Dentist		
Bouchard et al. [40]			N/A			**Good**	**Moderate**	**Poor**
	CTG	Examiner A				13/15	2/15	0/15
		Examiner B				12/15	3/15	0/15
	CPF+CTG	Examiner A				7/15	8/15	0/15
		Examiner B				8/15	7/15	0/15
Rosetti et al. [27]			N/A			Good		Poor
	CPF +DFDBA+GTRrs					81.7%		0%
	CPF+ SCTG					80%		0%
Wang et al. [41]			Excellent	Good				
	CPF+GTRrs		9/16	4/16				
	CPF+SCTG		7/16	6/16				
Aichelmann-Reidy et al. [42]			Excellent	Good		Excellent	Good	
	CPF+ADM		13/22	9/22		18/22	4/22	
	CPF+SCTG		9/22	11/22		7/22	12/22	
Zucchelli et al. [43]			Optimum	Good				
	Test		8/15	7/15				
	Control		0/15	8/16				
Cheung and Griffin [44]	CPF+PCG		No overall esthetic evaluation was performed					
	CPF+CTG							
Kerner et al. [45]	Pedicle soft tissue grafts/Non-submerged grafts/ Submerged grafts/ Envelope technique	Periodontist 1				72.2%		
		Periodontist 2				73.4%		
		Nurse				71%		
Bittencourt et al. [18]	SCPF		8/17	6/17	3/17			
	SCTG		12/17	5/17	0.17			
Cairo et al. [53]	CPF, FGG, CTG, DPF, or combination		No overall esthetic evaluation was performed					
Jhaveri et al. [55]	CPF+ADM+F CPF+SCTG		No overall esthetic evaluation was performed					
Cairo et al. [54]	CPF, FGG, CTG, DPF, EMD, or combination		No overall esthetic evaluation was performed					
McGuire and Scheyer [38]	C: CPF+SCTG T: CPF+CM		No significant difference					
McGuire et al. [51]	C: CPF+CTG		N/A			Texture equivalent	Color equivalent	
						5/9	6/9	
	T: CPF+EMD					8/9	8/9	

Cheung and Griffin [44] assessed the clinical efficacy of platelet concentrate grafts (PCG) plus collagen sponge as a carrier in the treatment of Miller Class I or II gingival recessions (≥ 2 mm) and compared to those of SCTG in regards to soft tissue healing. Fifteen patients completed the study. The location of the treated tooth was not described in the text, but figures on maxillary canines and premolars were presented **(Table 3)**. Three experienced and masked periodontists examined the 8-month post-surgical clinical photos. Color match, tissue texture, and contour of the surgical area were documented and compared to the adjacent tissue. Ideal color match was defined as the color of gingival tissue at the grafted site matched with the adjacent non-surgical area. Ideal tissue contour means the tissue at the grafted area had a natural thickness that harmonized well with the adjacent non-surgical tissue. Ideal tissue texture means the tissue at the grafted area had a smooth surface that blended in well with the adjacent non-surgical tissue. The scoring range was from 1 (most favorable) to 4 (least favorable) **(Table 4)**. Esthetic

outcomes showed all the examiners agreed that the PCG group yielded a better texture and contour **(Table 5)**.

Bittencourt et al. [18] compared the long-term outcome of SCPF and SCTG for the treatment of Miller Class I (≤ 4 mm) gingival recession defects in maxillary canines or premolars **(Table 3)**. A questionnaire was given to each patient at 6 and 30 months after surgery. Patients expressed their opinion on each treated tooth by selecting one of the following judgements: bad, sufficient, good, or excellent **(Table 4)**. In the SCPF group, 14/17 (82.35%) patients reported an excellent or good esthetic result, and 3 reported a bad result. All (100%) subjects in the SCTG group indicated an excellent or good result. After 30 months, all cases using SCPF showed scar tissue with variant in extent. However, only 7 patients complained about the scar appearance **(Table 5)**.

Kerner et al. [45] evaluated the esthetic outcome using a before-after panel scoring system on pre- and post-operative photographs. This was a retrospective study in 7 private practices to evaluate esthetic outcome using four types of RC procedures (pedicle soft tissue grafts, non-submerged grafts, submerged grafts, and envelope techniques) and to identify factors related to esthetic assessment **(Table 3)**. Eight parameters were assessed: overall esthetic appearance, degree of RC, color match, texture match, volume match, lack of hypertrophic scars, existing KT, and gingival contour. Photographs from 133 patients with 281 recession defects were rated by 2 independent periodontists and one nurse. Follow-up time ranged from 6 to 130 months, with a median of 11.72 months. The esthetic results were scored using the following five-point ordinal improvement scale: poor, fair, good, very good, and excellent **(Table 4)**. Good to excellent overall esthetic results were identified by the three examiners in ≥ 70% of the surgical procedures **(Table 5)**. The presence of scars was the most frequent parameter taken into account by the periodontists when assigning unfavorable ratings during the cosmetic assessment. Moreover, non-submerged grafts were less esthetic than three other procedures and negatively influenced the esthetic outcome. On the other hand, the length of follow-up is a positive predictive factor for esthetic evaluation, indicating that esthetics is time dependent. It was suggested that the follow-up period in the future studies should be greater than 12 months.

Literature has suggested that the follow-up period on all cases after FGG be at least 1 year for the occurrence of creeping attachment [46]. The creeping attachment was described as the positive migration of the ginigval margin in a coronal direction. This migration often continues for long periods after surgery until a constant marginal level is reached. Matter [47] reported the phenomenon of creeping attachment after placing FGGs for a period of 5 years in 10 patients who had gingival recession less than 3 mm in width and length. There were two phenomenons: bridging and creeping attachment. Bridging is the establishment of collateral circulation, and creeping attachment is the coronal migration of the soft tissue margin. One month after grafting, the phenomenon of bridging was measurable in four cases. The creeping attachment occurred in all cases between 1 month and 1 year after surgery. In addition, Harris [48] examined 22 defects in 19 patients treated with CTG plus partial-thickness double pedicle flap and also obtained a mean creeping attachment of 0.8 mm 6 to 9 months after the surgery. These quantitative results are correspondent with the qualitative results in Kerner's study [45] indicating that follow-up period/time is an important factor affecting the esthetic outcome of the PPS.

Kerner et al. [49] also showed that neither the percentage of RC nor ginigval augmentation was correlated to cosmetic assessment. The amount of the RC is not the most critical variable in the overall esthetic judgement of the observers. Instead, soft tissue appearance was significantly associated with cosmetic assessment. In particular, the color of the soft tissue was a prominent predictive factor. This is in contrast to the study by Rotundo et al. [50], who showed CRC was perceived as the most successful outcome by patients, general dentists, and periodontists. However, the latter study evaluated gingival recession depth, color of the exposed root, amount of RC, but not soft tissue parameters. Consequently, percentage of RC cannot be the main goal of PPS that aim to improve global esthetic appearance of patients' smile.

Comparing to adjacent tissue: McGuire and Scheyer [38] determined if a xenogeneic collagen matrix with CPF might be as effective as CTG+CPF in the treatment of recession defects. Molars were excluded, but specific tooth location and tooth type were not described in the text. Figures illustrating pre- and post-surgery comparison on maxillary canines were shown **(Table 3)**. A masked and calibrated examiner assigned color and texture binary ratings of "equal or not equal to surrounding native tissue" through visual observation and palpation. Examinations on patients were performed in the clinic and not by the comparison of photographs **(Table 4)**. No statistically significant differences could be discerned between these two groups in terms of color or texture match to surrounding tissue **(Table 5)**.

McGuire et al. [51] also examined the major qualitative and quantitative parameters of a previous Miller Class I and II gingival recession study 10 years after treatment with either CTG+CPF or EMD+CPF. Nine of 17 original patients were available after a 10-year follow-up. Qualitative parameters were evaluated on nine pairs of teeth from 9 available patients **(Table 3)**. Gingival color, texture, and contour were assessed by a single blinded examiner in comparing treatment sites from both groups to adjacent tissues and scored through questionnaires **(Table 4)**. EMD-treated sites tended to be more likely to exhibit equivalent texture and color to adjacent tissues as compared to CTG-treated sites, although the difference of both parameters failed short of achieving statistical significance **(Table 5)**.

Non-autogenous approach was advocated due to the elimination of the need for a secondary harvesting procedure and reduction of treatment time. It also seemed to result in a more favorable esthetic appearance [38,41-43,52]. However, it should be pointed out that these studies were all supported by commercial companies.

Root coverage esthetic score (RES): Cairo et al. [53] proposed a scoring system, namely the root coverage esthetic score (RES), for evaluating the esthetic outcome following RC surgery. Thirty-one patients with Miller Class I and II recession defects were treated with different RC procedures (pedicle flaps, soft tissue grafts, or combinations). Patients were evaluated 6 months after surgery by a periodontist using RES system. The RES system assesses 5 variables: level of the gingival margin, marginal tissue contour, soft tissue texture, mucogingival junction alignment, and gingival

color. The value assigned for the RC variable was 60% of the total score, whereas 40% was assigned to the other four variables. With regard to the assessment of the final position of the gingival margin, 6 points were given for CRC and 3 points for partial RC; while 0 points were assigned when the final position of the gingival margin was equal or apical to the previous recession. One point was assigned for each of the other four variables. As a consequence, 10 points added up as a perfect score. The results in this study showed a mean RES of 7.8. CRC with a perfect score (RES=10) at 6 months was found in 5 out of 24 cases. In one case, RES=0. The authors suggested that the RES system may be a useful tool to assess the esthetic outcome following RC procedures. Later, a multicenter study evaluated the inter-examiner agreement of the RES among 11 experienced periodontists and further confirmed that the RES seems to be a reliable method for assessing the esthetic outcomes of RC procedures [54]. Moreover, Jhaveri et al. [55] compared the clinical efficacy of an ADM seeded with autologous gingival fibroblasts placed under a CPF (test) to a SCTG under a CPF (control) in respect to RC. Ten patients with bilateral Miller Class I or II gingival recession defects ≥ 2 mm and affecting contralateral canines or premolars in the maxillary arch were selected. The final esthetic outcome of the grafted sites at the end of 6 months was assessed by a calibrated dentist using the RES. The mean RES for the test and control group was 8.1 and 7.9, respectively, in which no significant differences between these two groups were found. In all, 13 cases (7 test and 6 control) achieved CRC. Among them, only 7 had an RES=10 **(Table 6)**.

Periodontist preference vs patient satisfaction: The esthetic results can be assessed by professionals and/or by patients. Once RC has been achieved, other factors like gingival thickness and color blending become important in the evaluation of the esthetic outcome of a RC procedure. It is the patient who judges surgery results, while it is the surgeon who selects the technique used. Kokich et al. [56] compared the perceptions of dentists and lay people with respect to tooth size and alignment and their relation to the adjacent soft tissues in maxillary esthetic zone. The results show that specific dental esthetic discrepancies were detected at varying levels of deviation by lay people and dental professionals. Dental professionals were generally sensitive to minor dental disharmonies, whereas the lay people were unable to detect disharmonies in several of the esthetic variables. Therefore, professionals may develop opinions of an esthetic appearance that differ from those of patients.

Conclusions

The final esthetic goal of a root coverage procedure should include the achievement of complete root coverage and complete soft tissue integration.

Table 6 RES system [53].

*The ideal esthetic score was 10; †Zero points were assigned if the final position of the gingival margin was equal or apical to the previous recession depth (failure of root coverage procedure), irrespective of color, the presence of a scar, MTC, or MGJ; ‡Zero points were also assigned when a partial or total loss of interproximal papilla (black triangle) occurred following the treatment.

Level of the gingival margin (GM)	0 points	Failure of root coverage (gingival margin apical or equal to the baseline recession
	3 points	Partial root coverage
	6 points	Complete root coverage
Marginal tissue contour (MTC)	0 points	Irregular gingival margin (does not follow the CEJ)
	1 point	Proper marginal contour/scalloped gingival margin (follows the CEJ)
Soft tissue texture (STT)	0 points	Scar formation and/or keloid like appearance
	1 point	Absence of scar or keloid formation
Mucogingival junction alignment (MGJ)	0 points	MGJ not aligned with the MGJ of adjacent teeth
	1 point	MGJ aligned with the MGJ of adjacent teeth
Gingival color (GC)	0 points	Color of tissue varies from gingival color at adjacent teeth
	1 point	Normal color and integration with the adjacent soft tissues

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