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Subepithelial connective tissue graft with or without enamel matrix derivative for the treatment of Miller class I and II gingival recessions: a controlled randomized clinical trial

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Background: The aim of this study was to evaluate whether the combination of enamel matrix derivative (EMD) with subepithelial connective tissue graft (SCTG) plus coronally advanced flap (CAF) would improve the treatment outcomes of Miller class I and II gingival recessions when compared with the same technique (SCTG plus CAF) alone.

Methods: The study was designed as a randomized, parallel, controlled, double-blinded clinical trial. Forty-two patients were randomly assigned in the test group (SCTG plus EMD) and in the control group (SCTG). Patients had at least one gingival recession $\geq$ 2 mm. The clinical parameters were evaluated at baseline and at 14 d, 1, 3, 6 and 12 mo follow-up time points.

Results: Forty-two patients, 21 in the test group (SCTG plus EMD) and 21 in the control group (SCTG), aged 21–48 years (mean age 31 $\pm$ 8.56) were initially included in the study. Both treatments, STCG plus EMD and SCTG, resulted in a significant final mean root coverage (2.91 $\pm$ 0.95mm and 2.91 $\pm$ 1.29 mm, respectively) ($p < 0.001$) and in a high mean percentage of root coverage (82.25 $\pm$ 22.20% and 89.75 $\pm$ 17.33%, respectively) ($p < 0.001$), 1 year after surgery. The differences in mean root coverage recorded for the two techniques after 1 year, were not statistically significant ($p = 0.19$). Complete root coverage was achieved in 56.5% of patients treated with SCTG plus EMD and in 70.6% of patients treated with SCTG ($p = 0.275$), 1 year after treatment.

Conclusions: The present study failed to demonstrate any additional clinical benefits when EMD was added to SCTG plus CAF.

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Gingival recession (GR) is a common feature seen in many patients. Some patients are unaware of the condition, but in many instances, GR may be a concern because of esthetic problems, root hypersensitivity or fear of tooth loss (1).

The major aims of GR treatment are full coverage of the exposed surface, gingival dimension increase and optimal esthetic appearance (2). The ultimate goal of surgical coverage techniques is to regenerate lost periodontal structures at the level of the diseased root surface–graft interface (3).

Several surgical procedures are available to cover the exposed radicular surface, including pedicle flaps, free soft tissue grafts, combination of pedicle flaps plus subepithelial connective tissue graft (SCTG) or barrier membranes, and are associated with different rates of success and predictability (4,5).

SCTG plus coronally advanced flap (CAF) presents a high degree of predictability when used to treat Miller (6) class I and II GRs (7). Recent systematic reviews (8–10) have demonstrated that techniques using SCTG are predictable for treating GRs and provide a good homogeneity of color between the covered area and surrounding gingiva. Moreover, SCTG plus CAF seems to be the gold standard because of its favorable outcomes for root coverage (10).

To increase the efficacy of root coverage techniques, additional approaches have been proposed such as enamel matrix derivative (EMD) (11,12), platelet-rich fibrin (13), acellular dermal allograft (14), non-resorbable barriers (15) or bioabsorbable barriers (16,17).

EMD is an amelogenin derivative of porcine origin (18) having an enhanced potential to regenerate periodontal tissues as revealed by clinical (19,20) and histological data (21,22).

EMD has been suggested to be effective in improving the clinical attachment level when it has been associated with surgical root coverage techniques, by case reports (23), clinical studies (12) and randomized clinical trials (24,25).

Topical application of EMD has been beneficial in augmenting the effects of CAF in terms of the amount of root coverage, gain in clinical attachment, and in increasing the apicocoronal dimension of the keratinized tissue (12). Other studies have found that the addition of EMD to CAF resulted in no clinical improvements of root coverage when comparing with CAF alone (26,27). The addition of EMD to CAF results in root coverage similar to the SCTG plus CAF (28,29).

Randomized clinical trials have shown contradictory results on the effect of EMD when associated with SCTG. A significant positive effect of EMD has been observed by Henriques *et al.* (25) who treated Miller class III GRs, while in the treatment of Miller class III GRs Aroca *et al.* (30) demonstrated that EMD did not enhance the mean clinical outcomes.

Up to now, a single randomized clinical controlled trial (31) recently compared the clinical outcomes of SCTG alone and in combination with EMD in the treatment of Miller class I and II GRs. As its results challenge again the positive effect of EMD when associated with SCTG in treating GRs, there is need for more studies on this subject.

Independently of the abovementioned trial, the aim of this study was to investigate whether the addition of EMD to SCTG plus CAF would improve treatment outcomes of Miller class I and II GR defects.

Material and methods

Study design and randomization

The study was designed as a randomized, parallel, controlled, double-blinded trial comparing SCTG plus EMD (test group) with SCTG (control group) for the treatment of single or multiple GRs.

The patients were randomly allocated in one of the two treatment groups. The allocation ratio was 1 : 1.

Study population

The subjects were selected from a group of patients (112 patients) referred to the Department of Periodontology, Iuliu Hatieganu University of Medicine and Pharmacy (Cluj-Napoca, Romania) with esthetic concerns, fear of tooth loss and root hypersensitivity. The therapy addressed these complaints by surgical attempts to cover the exposed root surfaces.

The following inclusion criteria had to be satisfied for a patient to be enrolled into the study: age $\geq$ 18 years; no relevant systemic diseases; full-mouth plaque score (32) $\leq$ 20%; smoking $\leq$ 10 cigarettes/day; presence of at least one Miller class I or II buccal GR $\geq$ 2 mm, and an identifiable cemento-enamel junction (CEJ); probing depth $\leq$ 3 mm without bleeding; absence of caries or restorations in the area to be treated; no history of mucogingival surgery at the experimental site; and no systemic diseases that could influence treatment outcome. All the Miller class I and II GRS included in the study were assimilated with the recession type 1 proposed by Cairo *et al.* (33). After patient enrollment, the study protocol, risks, estimated benefits, and procedural details were explained and written informed consents were obtained from all subjects. In obtaining informed consent and conducting the study, the study adhered to principles outlined in the Declaration of Helsinki on experimentation involving human subjects. The study was approved by the Ethical Board of Iuliu Hatieganu University (no 54/3.12.2008).

Initial therapy

After enrollment, all patients received oral hygiene instructions to modify habits related to the etiology of GRs at least 1 mo before surgery. Initial therapy (consisting of ultrasonic scaling and polishing) was performed 1 mo before surgery.

Surgical procedure

After achieving local anesthesia using injectable articaine 4% plus epinephrine, the protocol followed a modification by McGuire and Nunn (28) of

the technique described by Langer and Langer (34) so the flap could cover the entire graft. An initial intrasulcular incision was made using a no. 15 blade (Swann-Morton, Sheffield, UK) at the buccal aspect of the involved teeth. Then, without interfering with the gingival margin (GM) of the neighboring teeth, two vertical releasing incisions with a slight apical divergence designed the two external surgical papillae; the incisions were extended beyond the mucogingival junction (MGJ). A full-thickness trapezoidal flap was elevated up to the MGJ then a split-thickness flap was dissected further apically. The periosteum at the base of the flap was dissected and the flap was undermined until a tension-free coronal positioning was allowed. A de-epithelization of the adjacent papillae was performed using microsurgical scissors (Micro Curved Castroviejo Scissor; Hu-Friedy Mfg. Co., Chicago, IL, USA). Root planing of the exposed root surface between the CEJ and the coronal limit of the former recession was performed with Gracey curettes (7/8 Standard Gracey Curette; Hu-Friedy Mfg. Co.), in order not to remove the vital periodontal ligament. The SCTG was obtained from the palatal area of the two premolars using a single incision technique (35), to minimize postsurgical complications. The donor site was secured with modified horizontal mattress sutures using a 4-0 resorbable suture (Vicryl®; Johnson & Johnson Intl, St-Stevens-Woluwe, Belgium).

At this point, EDTA (EDTA®; Straumann Biologics Division, Basel, Switzerland) was applied only on the test sites, as recommended by the manufacturer. EMD (Emdogain®; Straumann Biologics Division) was applied on the conditioned root surfaces of the test sites by starting at the base of the recession and covering the entire root surface.

In both groups, the SCTG was adapted to cover the exposed roots about 1 mm beyond CEJ and was stabilized with 5-0 resorbable sutures (Vicryl®; Johnson & Johnson Intl.). The flap was coronally positioned and secured with 5-0 resorbable sutures (Vicryl®; Johnson & Johnson Intl.) to completely cover the graft, using sling and interrupted sutures.

Postsurgical instructions

The following postoperative regimen was prescribed to all patients: intermittent application of an ice bag on operated area for the first 5–6 h to control swelling; control of postoperative pain and edema with ibuprofen, 400 mg, 2 times/day, for the first day and then if necessary; rinses with 0.2% chlorhexidine digluconate (Corsodyl®; GlaxoSmithKline Consumer Healthcare GMBH&co., Herrenberg, Germany), twice a day for 3 wk. Patients were told to discontinue tooth brushing and avoid trauma and food impaction at surgical sites for the next 3 wk. Sutures were removed after 14 d. At each follow-up visit, patients received one session of prophylaxis, including reinforcement of oral hygiene, and professional tooth cleaning.

Clinical measurements

Clinical measurements and photographs were taken at baseline and at follow-up postoperatively: 14 d, 1, 3, 6 and 12 mo. Measurements took as the reference point the CEJ, were performed with a manual probe (UNC-15 periodontal probe; Hu-Friedy) and rounded up to the nearest millimeter. Where the CEJ appeared unclear, a magnification device (Eye Mag Pro F; Carl Zeiss AG, Oberkochen, Germany) was used.

The following parameters were assessed at baseline: (i) recession height (RH) (distance from the CEJ to the most apical extension of the GM (36); (ii) intraoperative RH or hidden recession (distance from the CEJ to the marginal bone on the mid-buccal site, measured after flap elevation); (iii) recession width (RW) [distance measured from one border of the recession to another, at the CEJ (37)]; (iv) keratinized gingiva width (KGW) [distance from the most apical point of the GM to MGJ highlighted by using the functional method: running a horizontally positioned periodontal probe from the vestibule towards the GM with light pressure (38)]; (v) probing depth (PD; distance from the GM to the bottom of the gingival sulcus on the mid-buccal site); and (vi) presence of cervical lesions. After surgery, RH was measured at all follow-up time points, KGW at all follow-up time points except that of 14 d and PD was assessed only at 6 and 12 mo after surgery.

Full-mouth plaque score and bleeding on probing score were recorded at baseline as the percentage of total surfaces (four aspects per tooth) that had plaque and bleeding, respectively (32,39).

Esthetic evaluation

Esthetics was assessed as a patient-centered outcome of surgical treatment. Patients evaluated the changes in esthetics at the 12 mo follow-up visit using a 1–10 visual analog scale (VAS). The levels of outcomes were classified using three appreciation scales. "No or minimal improvement" in esthetics was associated with 1–3 scores; "good esthetic improvement" was associated with scores of 4–6; "very good esthetic improvement" was associated with a score of 7–10 (40,41).

After 12 mo, an experienced independent investigator assessed the esthetic outcome of the root coverage procedures using dental loupes (Eye Mag Pro F; Carl Zeiss AG) under the same illumination source. Five variables were scored according to the root coverage esthetic score score (42) as follows: (i) GM level: score 0 = failure of root coverage; score 3 = partial root coverage; and score 6 = complete root coverage; (ii) marginal tissue contour: score 0 = irregular GM; score 1 = proper marginal contour; (iii) soft tissue texture: score 0 = presence of scar of keloid-like appearance; score 1 = absence of scar; (iv) MGJ alignment: score 0 = MGJ not aligned with MGJ on adjacent teeth; score 1 = MGJ aligned with MGJ on adjacent teeth; and (v) gingival color: score 0 = color of tissue in surgical area differs from gingival color on adjacent teeth; score

1 = normal color and integration with adjacent soft tissues. The best esthetic score was 10 and worse 0, which corresponded to failure of root coverage.

Results

The principal surgical outcome was root coverage (or recession reduction), which was measured in millimeters as the difference between baseline RH and postoperative RH. Root coverage was expressed as a percentage of root coverage of the original defect as well (root coverage rate). The root coverage rate was calculated using the following formula: $(RH_{baseline} - RH_{follow\text{-}up\ moment}) \times 100/RH_{baseline}$.

Secondary surgical outcomes were the complete root coverage rate, the creeping attachment (CA) (difference between RH measured at two consecutive follow-up time points), the gain in KGW (the difference between KGW at one follow-up time point and KGW at baseline) and esthetic evaluation.

Investigator training

All participating investigators attended two training and calibration meetings, in which they received instructions on the development of the trial, case selection, measurement techniques, surgical procedures, data compilation sheets and their precise role in the study. To evaluate intra-examiner reproducibility, four subjects, not involved in the study but matching the study criteria, were evaluated on two occasions, 24 h apart. The intraclass correlation coefficients, used as a measure of intra-examiner and interexaminer reliability, were 0.95 and 0.94, respectively.

Sample size

A difference of 1 mm in root coverage was considered as the minimum clinically significant difference between treatments. Using $\alpha = 0.05$, a power of 90%, equal standard deviation $\sigma = 0.80$ mm taken from previous studies (12,28,36) the calculated sample size was 15 patients per each treatment group.

Randomization

Patients were assigned to one of the two treatment groups using a computer-generated randomization table. The records of participants contained no mention about treatment allocation. A list containing allocation numbers and name of patients together with records was handed to the statistician, who was not aware of the type of treatment.

The recruitment of patients for the study and baseline measurements were performed by one investigator (SS). All measurements at follow-up visits were carried out by another examiner (AS). The allocation sequence was concealed from the investigators that enrolled and assessed patients. The envelopes containing allocation numbers were opened only at the time of interventions. The same experienced operator (AR) performed all the surgeries.

The following persons were blinded after being assigned to interventions: investigators who performed the baseline and follow-up measurements, patients and statistician.

Data analysis

Normality of continuous data was assessed using the Shapiro–Wilk test. Results were summarized using mean and standard deviation (SD) for the clinical parameters. Each GR represented a statistical unit. Taking into account the paired nature of changes from baseline to all follow-up time points in each group, the Wilcoxon signed-rank matched pair test was performed for the pairwise statistical analysis of continuous variables and the McNemar test was performed for the pairwise statistical analysis of nominal variables. The Mann–Whitney *U* test was applied to compare outcomes between test and control groups at baseline and at all follow-up time points. Cross-tabular analyses were performed using chi-squared or Fisher exact tests. The analyses were repeated for patient subgroups treated for single or multiple GRs. The level of significance was $\alpha = 0.05$. The data were statistically evaluated using the statistical program SPSS 15.0.

Results

Forty-two patients, 21 in the test group (SCTG plus EMD) and 21 in the control group (SCTG), aged 21–48 years (mean age 31 ± 8.56) were originally included in the study. Four patients (9.52%) in the test group were lost after the 14 d visit due to personal reasons. Therefore, 17 patients (mean age 34.09 ± 8.65) in the test group and 21 patients (mean age 30.18 ± 7.61) in the control group completed the study (Fig. 1). Patients were recruited from June to December 2009 and surgeries were performed from January to November 2010. The study ended on 2 December 2011. The number of treated GRs per patient ranged between one and three. All surgical areas healed uneventfully (Fig. 2).

No differences between the two groups were observed regarding the age (*t* test, $p = 0.06$), baseline and intraoperative RH ($p = 0.25$ and $p = 0.08$), RW ($p = 0.41$), KGW ($p = 0.88$) and presence of cervical lesions ($p = 0.08$).

In the test group, 23 teeth with GRs were treated: eight incisors, six canines, seven premolars and two molars. Thirteen surgeries treated a single GR, two surgeries treated two adjacent GRs and two surgeries treated three adjacent GRs.

In the control group, 34 teeth with GRs were treated: nine incisors, 11 canines, 12 premolars and two molars. Eleven surgeries treated a single GR, seven surgeries treated two adjacent GRs and three surgeries treated three adjacent GRs. No statistically significant difference was found between the test and control group in regard of number of GRs treated in a single surgery ($p = 0.32$).

One year after surgery for the SCTG plus EMD patients the mean RH significantly decreased from 3.74 ± 1.45 (baseline) to 0.83 ± 1.19 mm (1 year) ($p < 0.05$); the corresponding values for SCTG patients were 3.32 ± 1.36 mm and 0.41 ± 0.70 mm ($p < 0.05$) (Table 1).

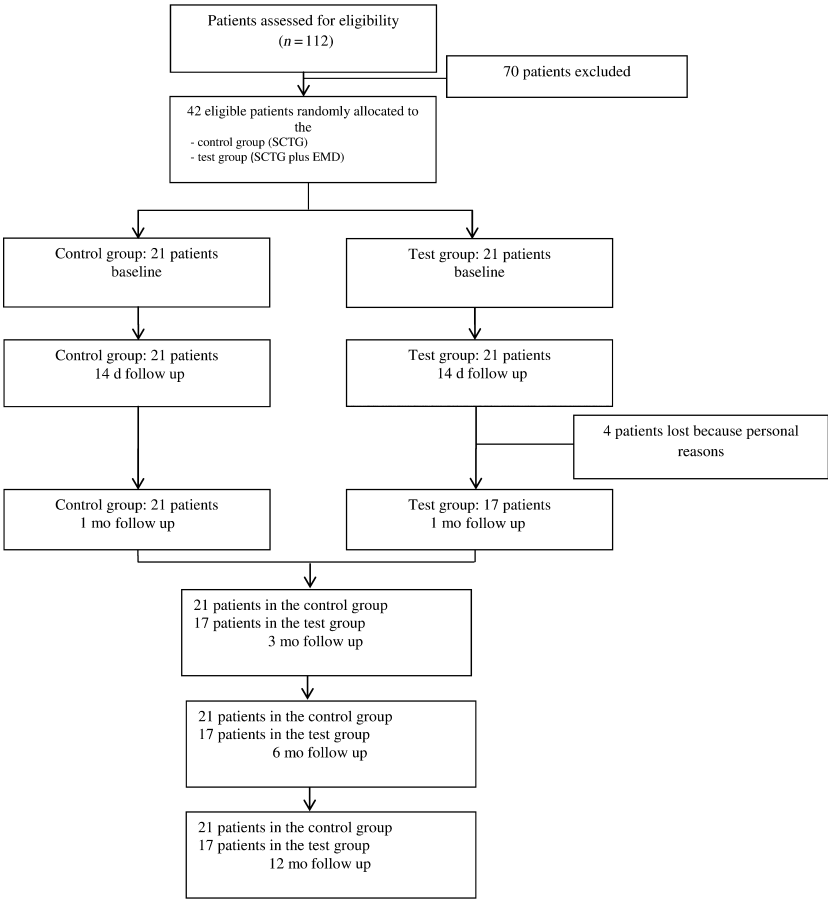

Fig. 1. Flowchart of the patients. EMD, enamel matrix derivative; SCTG, subepithelial connective tissue graft.

For both groups, RH values at all follow-up visits significantly modified ($p < 0.05$) when compared with baseline and intraoperative RH (Table 1). For both groups, KGW was significantly modified ($p < 0.05$) at all follow-up time points in comparison with respective baseline values; no significant modifications were recorded for PD. For both groups, the increase of PD at 6 and 12 mo follow-up time points in comparison with the baseline was not statistically significant. No statistical differences were observed between groups for RH, KGW and PD (Table 1).

Both treatments, STCG plus EMD and SCTG, resulted in significant ($p < 0.05$) final root coverage at 1 year postoperation (2.91 ± 0.95 mm and 2.91 ± 1.29 mm, respectively). The root coverage values significantly improved ($p < 0.05$) at all time intervals in comparison with baseline RH, for both groups, but there were no significant differences between the two groups (Table 2). When results were expressed as a percentage of root coverage after 1 year, both treatments (SCTG plus EMD and SCTG) resulted in root coverage of $82.25 \pm 22.20\%$ and $89.75 \pm 17.33\%$, respectively. The root coverage rates at all follow-up time points are shown in Table 2.

The mean root coverage rates were deducted for single and multiple GRs (Fig. 3).

For SCTG plus EMD, complete root coverage after 14 d, 1, 3, 6 and 12 mo were observed in 11, 13, 13, 13 and 13 GRs, respectively. The corresponding values for SCTG were 17, 20, 23, 24 and 24 GRs. The correspondent percentages are shown in Table 3. The differences of complete root coverage rates for each group and between the two groups were not significant ($p > 0.05$) (Table 3).

A significant increase in KGW was observed in both groups ($p < 0.05$) (Table 3).

For the control group, the CA phenomenon significantly ($p < 0.05$) better develops in the first 6 mo in comparison with the last 6 mo of the follow-up period. The modifications due to CA were not significant either for each group or between groups (Table 3).

CA was recorded for three treated GRs in the test group and for seven treated GRs in the control group and contributed to complete root coverage of all of these GRs, excepting one GR in the test group. The same 1 mm dimension of CA was recorded for all teeth.

Root coverage rates at all follow-up time points were significantly influenced by baseline RH in the test group (r between 0.56 and 0.69, $p \leq 0.01$) and in the control group ($r = 0.86$–0.88, $p < 0.001$) and also by intraoperative RH in the test group (r between 0.45 and 0.61, $p \leq 0.03$) and in the control group (r between 0.78 and 0.83, $p < 0.001$).

The RW significantly correlated with root coverage values only for the test group ($r = 0.48$, $p = 0.03$) but not for the control group (r between 0.11 and 0.18, $p \geq 0.33$). The baseline KGW did not correlate with root coverage rates for either of the groups (r between 0.13 and 0.27, $p \geq 0.21$; r between -0.10 and -0.03, $p \geq 0.60$, respectively).

The age, tooth type, associated cervical lesions and number of GR treated in a single surgery did not significantly correlate with the rates of root coverage, for either of the groups.

The mean VAS score for esthetics was 8.70 ± 1.57 for the test group and for the control group 8.95 ± 1.49. No VAS scores less than 5 were recorded in both groups. Moreover, 82.35% of patients in the test group and 95.23% of patients in the control group reported very good improvement in esthetics (score 3). No statistically significant difference between groups was demonstrated in terms of esthetic satisfaction ($p = 0.62$). The root coverage esthetic scores were 8.58 ± 1.54 for

Fig. 2. Class I Miller gingival recessions on a maxillary left first molar: (A) preoperative clinical appearance; (B) sutured overlying flap; (C) clinical appearance at 14 d; (D) clinical appearance at 3 mo.

Table 1. Mean ± SD of all monitored parameters at baseline and follow-up time points

Follow-up parameters	Moment of examination	Test group	Control group	*p*-Value
RH	Baseline	3.74 ± 1.45	3.32 ± 1.36	0.25
	Intraoperative	6.00 ± 1.91	5.24 ± 1.81	0.08
	14 d	0.96 ± 1.07*	0.62 ± 0.70*	0.32
	1 mo	0.87 ± 1.22*	0.53 ± 0.71*	0.5
	3 mo	0.83 ± 1.19*	0.44 ± 0.70*	0.28
	6 mo	0.83 ± 1.19*	0.41 ± 0.70*	0.21
	12 mo	0.83 ± 1.19*	0.41 ± 0.70*	0.21
KGW	Baseline	2.43 ± 1.27	2.38 ± 0.98	0.88
	1 mo	3.78 ± 1.00*	3.72 ± 0.68*	0.87
	3 mo	3.75 ± 0.82*	3.69 ± 0.69*	0.96
	6 mo	3.74 ± 1.01*	3.72 ± 0.77*	0.99
	12 mo	3.75 ± 1.01*	3.72 ± 0.77*	0.99
PD	Baseline	1.30 ± 0.56	1.59 ± 0.50	0.06
	6 mo	1.57 ± 0.51	1.55 ± 0.51	0.89
	12 mo	1.57 ± 0.51	1.55 ± 0.51	0.89

*$p < 0.05$ when comparing with baseline. KGW, keratinized gingiva width; PD, probing depth; RH, recession height.

the treatment group and 9 ± 1.09 for the control group but the differences were not significant ($p = 0.343$).

Discussion

The purpose of the present randomized, controlled clinical study was to evaluate the possible clinical benefit of EMD when associated with SCTG to cover Miller class I and II GRs. SCTG plus EMD (test group) treated 23 GRs and SCTG (control group) treated 34 GRs. Both treatments were effective in reducing RH; both techniques resulted in a high percentage of root coverage (82.25 ± 22.20% in the test group and 89.75 ± 17.33% in the control group). The results were comparable with those of other studies (30,31,43).

Furthermore, data in the present study showed that complete root coverage was achieved in 56.5% of the patients treated with SCTG plus EMD and in 70.6% of the patients treated with SCTG. Rasperini *et al.* (31) recorded a higher complete root coverage rate for SCTG plus EMD (62%) than for SCTG (47%). Another study with a similar design showed a 38% complete root coverage value for both groups (30), but they treated Miller class III GRs whose coverage is less predictable.

The tooth type seemed not to influence the therapeutic results, for either of the groups. The posterior sites (bicuspids and molars) were included in the present study bearing in mind the concern for patients in terms of root hypersensitivity, negative esthetics or fear of tooth loss. The small number of molars in our study (two for both groups) is likely to have had little influence on the overall data.

Our study showed that the combined use of SCTG plus EMD was not associated with any improved gain in root coverage. The result might be linked to the high efficacy of the SCTG (10,30). Data in the present study are in concordance with those in Rasperini *et al.* (31) who performed a study with quite a similar design to ours reporting 90% and 80% root coverage rates after 1 year, for test and control groups, respectively. The results obtained by the reported research are also in concordance with those of Aroca *et al.* (30), which revealed 82% and 83% root coverage rates after 1 year, for test and control groups, respectively. However, they treated multiple Miller class III GRs and employed a slightly different surgical protocol.

On the other hand EMD associated with SCTG showed significantly better results in recession depth reduction compared with SCTG alone when Miller class III GRs were treated (70% vs. 54.8% root coverage rates) (25).

Table 2. Mean root coverage

Principal surgical outcome	14 d	1 mo	3 mo	6 mo	12 mo
Root coverage (mm)					
Test	2.78 ± 1.13*	2.87 ± 0.97*	2.91 ± 0.95*	2.91 ± 0.95*	2.91 ± 0.95*
Control	2.71 ± 1.45*	2.79 ± 1.37*	2.88 ± 1.30*	2.91 ± 1.29*	2.91 ± 1.29*
p-Value	0.38	0.35	0.37	0.46	0.46
Root coverage (%)					
Test	75.98 ± 22.74*	81.16 ± 23.16*	82.25 ± 22.20*	82.25 ± 22.20*	82.25 ± 22.20*
Control	81.17 ± 20.72*	84.85 ± 19.77*	88.77 ± 17.67*	89.75 ± 17.33*	89.75 ± 17.33*
p-Value	0.42	0.59	0.27	0.19	0.19

*$p < 0.05$ in comparison with baseline recession height.

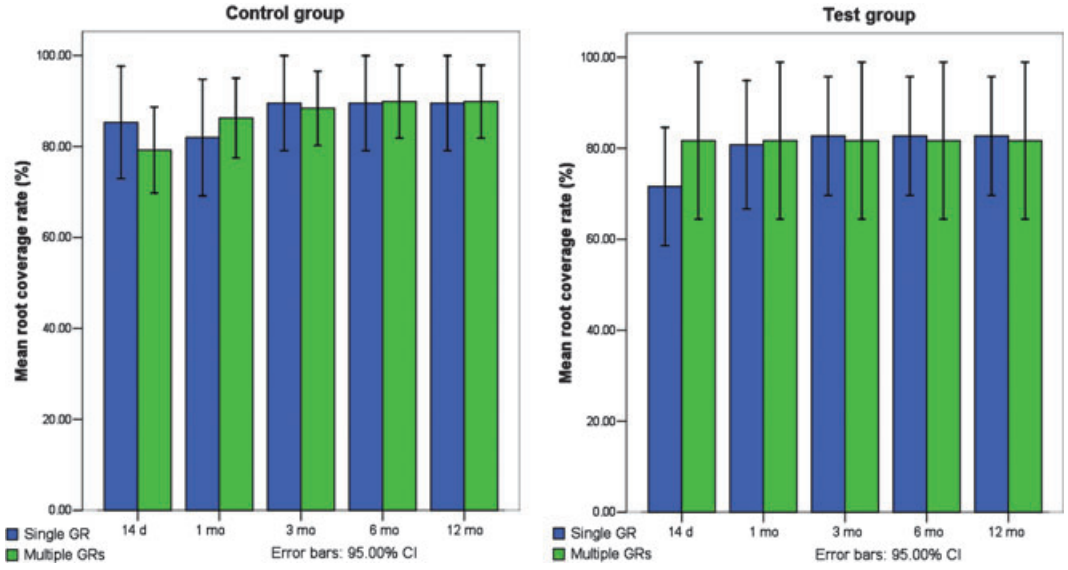

Fig. 3. Mean root coverage rates for single and multiple gingival recessions (GRs). (A) Control group. (B) Test group.

Table 3. Mean values for secondary clinical outcomes

Secondary surgical outcome	14 d	1 mo	3 mo	6 mo	12 mo
Complete root coverage (%)					
Test	43.5	56.5	56.5	56.5	56.5
Control	50.0	58.8	67.6	70.6	70.6
p-Value	0.629	0.863	0.393	0.275	0.275
Creeping attachment (mm)					
Test	–	0.09 ± 0.42	0.04 ± 0.21	0.00 ± 0.00	0.00 ± 0.00
Control	–	0.09 ± 0.45	0.09 ± 0.29	0.03 ± 0.18	0.00 ± 0.00**
p-Value	–	0.98	0.52	0.41	1
Gain of keratinized gingiva (mm)					
Test	–	1.41 ± 1.22*	1.36 ± 1.18*	1.36 ± 1.18*	1.36 ± 1.18*
Control	–	1.63 ± 1.18*	1.59 ± 1.19*	1.56 ± 1.22*	1.56 ± 1.22*
p-Value	–	0.61	0.57	0.67	0.67

*$p < 0.05$ when comparing with baseline KGW, keratinized gingiva width.
**$p < 0.05$ when comparing with 1 or 3 mo.

More abundant data on the influence of EMD in covering GRs are provided by studies that compared the efficacy of CAF plus EMD vs. CAF plus SCTG. CAF plus EMD and CAF plus SCTG procedures were similarly successful in treating Miller class I and class II single GRs: 92 ± 14% vs. 89 ± 14% and 73.2 ± 15.58% vs. 86.8 ± 12.48% (29,44).

The present study revealed that both surgeries resulted in a significant increase of KGW (1.36 ± 1.18 mm for the test group vs. 1.56 ± 1.22 mm for the control group), with no significant differences between the two groups. Despite the fact that additional use of EMD to procedures aimed to cover GRs had shown significant additional KGW gain (12,44) our study, just as the studies of Henriques *et al.* (25), Aroca *et al.* (30) and Rasperini *et al.* (31) failed to demonstrate additional KGW gain when the EMD was used. This might be because SCTG itself was associated with a significant gain of KGW.

The progressive coronal improvements of the GM levels in a 1 year period, in the SCTG plus EMD and SCTG groups were due to the CA effect. CA is the phenomenon of post-surgical migration of GM tissue in a

coronal direction, covering areas of previously denuded root surfaces (45). The CA phenomenon seems to be an important secondary outcome recorded by the present study as it contributed to the improvement of root coverage rates for both groups: from $75.98 \pm 22.74\%$ to $82.25 \pm 22.20\%$ for the test group and from $81.17 \pm 20.72\%$ to $89.75 \pm 17.33\%$ for the control group. Moreover, the CA effect increased the percentage of sites with complete root coverage in both groups, from 43.5% to 56.5% in the SCTG plus EMD group and from 50% to 70.6% in the SCTG group. Other studies demonstrated the effect of CA after SCTG in increasing complete root coverage rate from 34% after 6 mo to 45% 1 year after surgery (47). Our study demonstrated the CA phenomenon for both surgeries and so did the study of Henriques *et al*. (25). CA has improved root coverage only in the SCTG group in the study of Aroca *et al*. (30).

However, complete root coverage because of CA is not predictable in all situations (47) and for this reason a prolonged follow-up period is important to avoid rushing into therapeutic decisions.

The present study recorded 1 mm CA dimensions, but other studies revealed heterogeneous results: 7 mm and 9 mm (48), 3 mm and 2 mm (49) and 1.23 mm (50), after free gingival grafts; 1.79 mm after SCTG plus CAF (51); 0.5 mm after EMD plus a laterally positioned flap (52); and 2 mm after acellular dermal matrix (53).

The results of the surgeries seemed stable after 3 mo for the test group and after 6 mo for the control group. On the other hand, CA could be observed up to 12 mo (46) or 10–25 years (54) after surgery. However, no measurable CA after a long period (5 years) was observed (55).

CA occurred after surgical procedures covering all Miller classes of GRs (30,51,56).

In the present study, the baseline and intraoperative RH were risk factors for root coverage rate, for both groups. RW was a risk factor of root coverage only for the test group. No other risk factors for root coverage were identified.

All patients in the test group and control group judged the esthetic appearance as improved, as revealed by VAS scores of 8.70 ± 1.57 and 8.95 ± 1.49, respectively. These results are in agreement with those reported by other studies (36,41,57,58). As the patients and the periodontist might have different views on the esthetic outcome of the surgeries (59), the root coverage esthetic score (42) was evaluated as well. The findings of this evaluation were in accordance with the patient-centered assessment results; there were no significant differences in esthetic appearance between the two treatment groups, after 12 mo.

Several factors were shown to have a significant influence on CA such as width of the GRs, position of the soft tissue graft, and height of the interproximal bone and patient level of home care (47).

One limitation of the present study was the small number of the cases when the signification of CA was assessed. The exact role of CA in the development of root coverage is not still understood, and further studies with designs addressing to this clinical outcome should be realized, having in view the importance of CA in perfecting root coverage and esthetics. In addition to data provided by the recent multicentric clinical trial of Rasperini *et al*. (31), the results in the present study provide supplementary evidence in a domain with scarce information, which is the association of EMD to SCTG.

Conclusions

Both treatments, SCTG plus EMD and SCTG, proved clinically successful outcomes. The present study failed to demonstrate any additional clinical benefits when EMD was added to SCTG plus CAF, which suggests that the use of EMD would not be necessary from a clinical point of view. On the other hand, EMD might favor the early healing of periodontal soft tissue wounds and obtaining new connective tissue attachment. Because of the possible histologic benefits in terms of regeneration, the association of EMD to SCTG may be still an appealing treatment alternative.

Summary

Both EMD plus SCTG and SCTG resulted in a high mean percentage of root coverage, 1 year after surgery, but the addition of EMD to SCTG did not improve clinical outcomes.

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Conflict of Interest

The authors declare that there is no conflict of interest in any of the companies whose products are included in this article.

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