Received: 19 October 2017 | Revised: 13 December 2017 | Accepted: 23 January 2018

DOI: 10.1002/JPER.17-0619

JOURNAL OF Periodontology

ORIGINAL ARTICLE

Long-term evaluation (20 years) of the outcomes of subepithelial connective tissue graft plus coronally advanced flap in the treatment of maxillary single recession-type defects

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Abstract

Background: Subepithelial connective tissue graft with coronally advanced flap (SCTG + CAF) has been considered the best and most predictable root coverage procedure. Thus, the aims of this study are two-fold: 1) to evaluate the long-term outcomes following SCTG + CAF in the treatment of gingival recessions (GR) and 2) to explore the influence of several tooth/patient-related factors on the stability of gingival margin at 1 year and at 5,10, 15, and 20 years after surgery.

Methods: Forty-five patients with 45 maxillary GR (Miller's Class I or III) were treated with SCTG + CAF in a private practice between 1990 and 1997. Recession depth (RD), probing depth (PD), keratinized tissue (KT) width and patient/tooth-associated variables were recorded for each GR at baseline, 1, 5, 10, 15, and 20 years after surgery. Parametric, non-parametric, and logistic regression statistics were used throughout the study.

Results: A total of 21 Class I (44.67%) and 24 Class III (53.33%) GR were treated. Considering all the 45 GR, statistically significant improvements were found for RD in all evaluations ($P < 0.05$) compared with baseline data. Over the course of the study, mean root coverage (MRC) decreased from 74.23% (1 year) to 67.69% (20 years). Within maxillary Class I defects, complete root coverage (CRC) at 1-year follow-up was 57.14% (n = 12) and 47.62% (n = 10) at the end of study period, whereas MRC decreased from 82.37% to 77.62%, respectively. Within maxillary Class III recessions, CRC of 20.83% (n = 5) was found at both the 1-year and the 20-year follow-ups. On the other hand, MRC decreased from 66.55% to 58.18%, respectively. The results of logistic regression analysis showed that the achievement of CRC was associated with sites not presenting interdental tissue loss (i.e., Class I, odds ratio: 5.031, $P = 0.024$), whereas GR recurrence appeared associated with sites with attached KT < 2 mm (i.e., 5-, 10-, 15- and 20-year follow-ups), to teeth presenting root steps (i.e., 10- and 20-year follow-ups), and smoking (i.e., 15-year follow-up).

Conclusions: Positive RD reduction and KT improvements achieved by SCTG + CAF at short-term may be preserved long-term with the majority of the treated sites not displaying relapse of the gingival margin. Teeth lacking a minimal 2-mm width of

attached KT and presenting non-carious cervical lesions were more prone to develop an apical shift of the gingival margin during a 20-year follow-up period.

KEYWORDS
gingival recession, surgery, surgical flaps, therapy, tooth root

1 | INTRODUCTION

Since the mid-1950s, the collection of root coverage (RC) procedures has been constantly amplified through the development of surgical techniques, harvesting procedures, allogenic/xenogeneic biomaterials and the expertise gathered by clinical research acquired "in order to combine the advantages of function's reestablishment with improvement of aesthetics".[1]

The short-term outcomes (i.e., ≤24 months) achieved by several randomized and non-randomized controlled trials have clearly demonstrated that all RC procedures are safe and may lead to clinical significant gains in gingival recession depth (RD) and in clinical attachment level (CAL).[1–4] Conversely, there are clear differences between flap- and graft-based procedures in terms of keratinized tissue gains.[2–4] Recently, the American Academy of Periodontology (AAP) at its regeneration workshop pointed out important clinical questions/scenarios faced by clinicians in their daily practice, concerning "the best possible choice of treatment modality to satisfy their patients' needs."[2–4]

Information on the treatment of Miller[5] Classes I, II, and III clearly indicates that subepithelial connective tissue graft (SCTG)-based procedures lead to the best outcomes for clinical practice due to their superior percentages of coverage and improved possibility of completely covering the defects, as well as significant increase of keratinized tissue (KT) when compared with most of the other procedures.[2–4] Regarding the need of treating gingival recessions (GR) the recent systematic review by Chambrone and Tatakis[6] evidenced the following: 1) most of the patients seeking RC procedures are not periodontitis patients and their gingival recessions are most of the time associated with trauma (e.g. traumatic toothbrushing); 2) untreated GR patients don't experience spontaneous improvements; 3) GR in patients with good oral hygiene are highly likely to display RD increase during long-term follow-up; and 4) the presence and quality of marginal KT influences the odds of RD increase or development of new GR.[6]

The AAP Regeneration Workshop papers also pointed out that ≥70% of RD reduction might be predicted ≥2 years after treating the recessions, but complete root coverage (CRC) varies (up to 67.5% of variation) according to the RC procedure and the follow-up period.[2–4] Long-term studies are mandatory for the assessment of real treatment outcomes of a given procedure. For instance, the Consensus Report of European Workshop on Periodontology strongly advised that long-term results with at least 5 years of follow-up are needed to evaluate the stability of the clinical outcomes,[7] but the literature remains scarce in terms of RC outcomes beyond 10 years of follow-up.

Recently, three long-term (>20 years) clinical studies were published on soft tissue augmentation procedures (free gingival graft [FGG][8,9] and coronally advanced flap [CAF[10]]). In the first study,[8] after a follow-up period ranging from 18 to 35 years, sites treated with FGG showed coronal displacement and stability of the gingival margin with recession reduction up to CRC while contralateral untreated sites showed a tendency to increase the existing recessions or developing new recessions. A second trial[9] assessed the 25-year long-term "biologic remodeling" of periodontal dimensions of teeth showing marginal recessions treated with FGG promoting more favorable keratinized tissue dimensions and improved marginal tissue recession.[9] A third study[10] showed that the aging process, the condition of the interdental periodontal tissue, and the presence of an attached KT band <2 mm were negative factors influencing the stability of the gingival margin in almost half of the treated sites during the 20-year period of observation.

Regarding the so called "gold-standard procedure"[2–4] (i.e., SCTG), evidence is lacking as well. Therefore, the aim of this study was two-fold: 1) to evaluate the long-term (over 20 years) outcomes following SCTG + CAF in the treatment of Miller[5] Class I and III gingival recessions; and 2) to explore the potential influence of different tooth- and patient-related factors on the stability of gingival margin at 1 year and, 5, 10, 15, and 20 years after surgery.

2 | MATERIALS AND METHODS

2.1 | Study population

The study population consisted of a group of 45 patients (10 males and 35 females, including 13 smokers, aged 24 to 62 years; mean age: 42.22 years) treated in a private practice in Florence, Italy, between 1990 and 1997 and controlled during a 20-year follow-up period. The present cohort originates from a population of 124 patients showing 131 single

recession defects treated with SCTG + CAF procedure (i.e., bilaminar technique).[11] This was a group of systemically healthy, highly motivated and compliant individuals (recalls every 4 to 6 months over 20 years) presenting a good level of oral hygiene and no signs of active periodontal disease. Written consent was already obtained for all 45 patients included in the present study before the surgical treatment with agreement to use their data for the clinical trial during the previous published study in accordance with the Helsinki Declaration 1975 as revised in 2000 and 2008. The extension of the study was also approved by Ethical Committee AVC Careggi Hospital of Florence, Italy N°. 2014/0015326.

2.2 | Inclusion criteria

Systemically healthy patients >18 years, with no contraindications for surgery, no previous periodontal surgery on the involved sites and presenting high level of oral hygiene (plaque/bleeding score <20%) were considered eligible for inclusion. Maxillary single recession defects (Miller[5] Class I, II, or III) localized on incisors, canines, or premolars, exhibiting an identifiable cemento-enamel junction, and absence of plaque and bleeding on probing in the sites scheduled for the procedure were considered eligible for inclusion.

2.3 | Exclusion criteria

Medically compromised patients, pregnant women, molar teeth, mandibular defects, GR not displaying an identifiable CEJ, and teeth presenting presence of abrasion/erosion/caries/restorations involving both the root and the crown were excluded from the study.

2.4 | Measurements

Patient-related data demographic details such us, age, sex, and smoking history were recorded. The following clinical measurements were performed at baseline, at 1 year and 5, 10, 15, and 20 years after surgery by an examiner (PPC). A group of calibrated offset probes* (n = 20) was used for all clinical measurements throughout the study period. Measurements were rounded up the nearest millimeter. Periodontal measurements were recession depth (RD); probing depth (PD); keratinized tissue width (KT) (distance in millimeters from the gingival margin to the mucogingival junction); and presence/absence of interdental attachment loss measured by probing the adjacent interdental sites. Root surface variables were non-carious cervical lesions (NCCL) defined as any pronounced root surface discrepancy (≥1 mm) caused by traumatic abrasion and erosion of hard tissue (step) as measured with a periodontal probe perpendicular to the long axis of the tooth in the deepest point of the abrasion.[12]

* PCP-UNC 15 periodontal probe, Hu-Friedy, Chicago, IL.

2.5 | Presurgical treatment

Before surgery the 45 patients underwent a course of non-surgical periodontal therapy including provision of detailed oral hygiene instructions. Once the patients were periodontally stabilized and satisfactorily demonstrated the ability to maintain effective plaque control, root coverage procedures were carried out.

2.6 | Surgical technique

Root coverage procedures using a SCTG + CAF (bilaminar technique) were performed always by one surgeon (GPP). In brief, under local anesthesia, root surfaces were gently planed; in the presence of root discrepancies to facilitate the position of the flap on the root, efforts were carried out to reducing the concavity of the step using a sharp curet. The preparation of CAF started with an intrasulcular incision on the buccal aspect of the involved tooth extending mesio-distally to dissect the buccal aspect of the adjacent papillae and avoiding the gingival margin of the adjacent teeth.

Two oblique releasing incisions were carried out from the mesial and distal extremities of the horizontal incisions beyond the mucogingival junction. A trapezoidal full-thickness flap was raised towards the mucogingival junction; then a partial thickness dissection was made apically towards the marginal bone crest leaving the underlying periosteum in place. A mesio-distal and apical dissection parallel to the vestibular lining mucosa was performed to release residual muscle tension facilitating the passive coronal displacement of the flap. The papillae adjacent to the involved tooth were deepithelialized. After preparation of the CAF the bilaminar technique consisted of a withdrawal of palatal connective tissue. A first incision perpendicular to the underlying bone was performed 2 to 3 mm apical to the palatal gingival margin. Then a second incision parallel to the palatal surface was performed to separate the epithelium from the underlying connective tissue; a third incision parallel to the previous one, deeper than approximately 1 to 2 mm, allowed for the removal of the connective tissue graft. After the removal of the connective tissue, the epithelialized flap was repositioned and sutured on the grafted area favoring a rapid primary healing. The grafted connective tissue, of about 1- to 1.5-mm thick, was positioned in the recipient site to cover the exposed root surface, extending mesially and distally to the defect on the periosteum and on the deepithelialized papillary connective tissue. In case of root discrepancy, the connective tissue graft was placed over the lesion to fill the step facilitating the CAF stability. Absorbable interrupted and compressive subperiosteal sutures were carried out to stabilize the graft in the recipient site; then the pedicle flap is moved and sutured coronally using 5-0 silk sutures to cover the connective tissue graft completely.

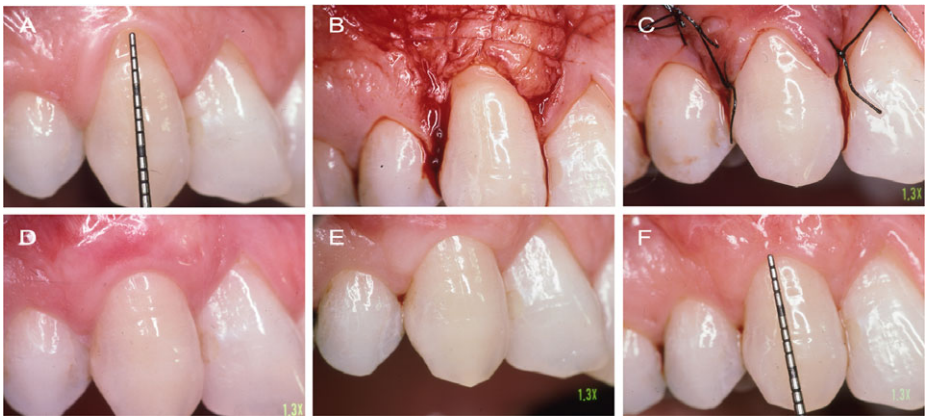

FIGURE 1 Case 1. **A**) Year 1997: Miller Class I gingival recession (2.5 mm) on the right maxillary canine, associated with 1 mm of KT, 1 mm of PD, and without NCCL. **B**) Following elevation of a pedicle flap, the connective tissue graft was sutured on the exposed root surface. **C**) The pedicle flap was sutured coronally covering the graft completely. **D**) 1 year after surgery the gingival margin was at CEJ level showing a complete root coverage and increased KT (3 mm). **E**) Year 2007: 10 years later the gingival margin is still at CEJ level. **F**) Year 2017: 20 years later the area showed stability

2.7 | Post-surgical care / follow-up

After surgery patients were instructed to discontinue toothbrushing; sutures of the flap were removed after 10 days. Three weeks later, the patients resumed mechanical tooth cleaning of the treated areas using a soft toothbrush and careful roll technique.Following surgical treatment, the patients were recalled at weeks 1, 2, 3, 4 and at 2 and 3 months for control and oral hygiene instructions. Then they were recalled every 4 to 6 months for reinforcement of oral hygiene instructions and supragingival plaque elimination during a follow-up period over 20 years.

Clinical outcome variables included CRC, mean root coverage (MRC), RD, pocket depth (PD), and KT width changes.

2.8 | Statistical analysis

Statistical analysis of clinical parameters (i.e., RD, KT, and PD) was carried out to compare the baseline values with 1, 5, 10, 15, and 20-year postoperative values using one-way analysis of variance (ANOVA) with repeated measures. If the assumption of sphericity was violated, Greenhouse-Geisser correction (for epsilon <0.75) or Huynh-Feldt correction (for epsilon >0.75) were used to correct the univariate results (i.e., adjust the *P* values). Moreover and, where appropriate, the Tukey test was performed to identify differences between means.

Since each patient contributed with only one defect, conventional logistic regression analysis was selected to evaluate the influence of some patient- and site-related factors on the achievement of sites with CRC 1 year after treatment, as well as GR recurrence at the 5-, 10-, 15-, and 20-year follow-up evaluations.

For the 1-year assessment, the binary dependent variable was CRC (yes, coded 1), and the independent variables were non-smoking (yes, coded 1), lack of interproximal tissue loss (yes, coded 1), lack of root step (yes, coded 1) and baseline RD < 4 mm (yes, coded 1). Regarding 5- to 20-year follow-ups, the binary dependent variable was GR recurrence (yes, coded 1) and the independent variables were smoking (yes, coded 1), presence of interproximal tissue loss (yes, coded 1), presence of root step (yes, coded 1), and attached KT < 2 mm (yes, coded 1). The odds ratio (OR) with its respective standard error (SE) and 95% confidence intervals (CIs) was calculated for each logistic regression model. The analyses were performed using a software package.* Differences at $P < 0.05$ were considered statistically significant.

3 | RESULTS

Out of the 124 patients treated in a previous study,[11] only 45 individuals meeting entry criteria (20-year follow-up) could be enrolled for the analysis. Out of the remaining 79 patients that could not be included in the current analysis, 54 did not achieve a 20-year follow-up, 15 interrupted the maintenance treatment, four died and six moved to another location. Therefore, data of these patients could not be reported in this study.

A total of 45 patients (32 non-smokers [71.11%]), each contributing with one GR were treated with SCTG + CAF and followed during the entire study period (20 years). Overall, a total of 45 maxillary teeth (13 incisors, 27 canines, and five premolars) were included. Two treated cases are shown in Figures 1 and 2.

3.1 | Clinical outcomes

Table 1 shows overall changes in RD, KT, and PD over the course of the study period. A total of 21 Class I (46.67%)

* Stata v.12.0, StataCorp, College Station, TX.

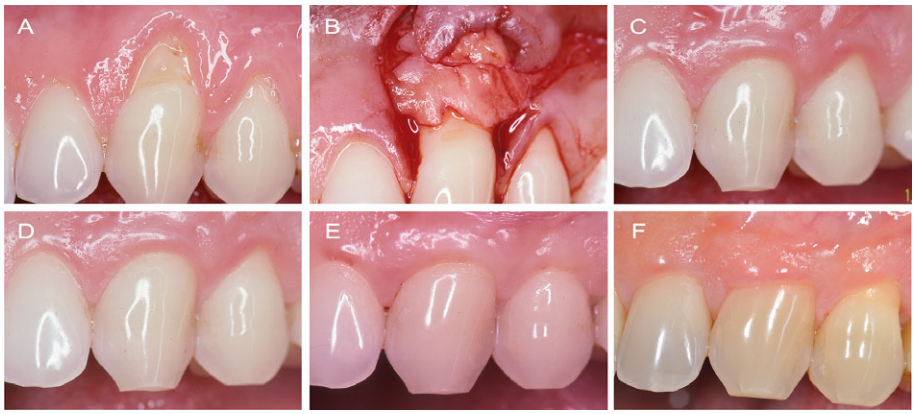

FIGURE 2 Case 2. **A**) Year 1995: Miller Class I gingival recession (5.0 mm) on the left maxillary canine associated with 1 mm of KT, 2 mm of PD, and presence of NCCL. **B**) Coronally advanced flap and connective tissue graft were performed. **C**) Healing 1 year after surgery. Complete root coverage was achieved with an increased KT (2 mm). **D**) Year 2000: after 5 years the gingival margin was stable and located at the CEJ level. **E**) Year 2005: after 10 years the gingival margin was still stable at the CEJ level. **F**) Year 2015: after 20 years the gingival margin was shifted coronally indicating that creeping attachment occurred in the last period of observation

TABLE 1 Clinical measurements at baseline and 1-, 5-, 10-, 15-, and 20-year follow-up: All gingival recessions

	Mean; SD (95% CI)]	*P* Value
RD		
Baseline	2.91; 1.01 (2.60 to 3.21)	* * * * *
1 year	0.75; 0.68 (0.55 to 0.96)	
5 year	0.84; 0.82 (0.59 to 1.09)	
10 years	0.84; 0.85 (0.58 to 1.10)	
15 years	0.88; 0.91 (0.61 to 1.16)	
20 years	0.95; 0.99 (0.65 to 1.25)	
KT		
Baseline	1.82; 0.98 (1.52 to 2.11)	* * * * *
1 year	2.93; 0.96 (2.64 to 3.22)	
5 years	2.91; 0.97 (2.61 to 3.20)	
10 years	2.80; 1.03 (2.48 to 3.11)	
15 years	2.71; 1.03 (2.39 to 3.02)	
20 years	2.68; 1.12 (2.35 to 3.02)	
PD		
Baseline	1.28; 0.50 (1.13 to 1.44)	
1 year	1.08; 0.28 (1.00 to 1.17)	
5 years	1.13; 0.34 (1.03 to 1.23)	
10 years	1.22; 0.43 (1.09 to 1.34)	
15 years	1.24; 0.43 (1.11 to 1.37)	
20 years	1.26; 0.44 (1.13 to 1.40)	

*Statistically significant (one-way repeated measures ANOVA test followed by the Tukey test [$P < 0.05$])

and 24 Class III (53.33%) GR were treated. Considering all the 45 GR, statistically significant improvements were found for RD in all evaluations ($P < 0.05$) compared with baseline data. Over the course of the study, MRC decreased from 74.23% (1 year) to 67.69% (20 years). Also, significant statistical changes were detected regarding mean width of KT (decrease) through some different time points ($P < 0.05$). Overall CRC achieved 1-year after treatment (n = 17/37.77%) decreased at 5- (n = 16/35.55%) and 10-,15- and 20-year (n = 15/33.33%) follow-ups. In terms of overall GR recurrence and creeping attachment (CA) occurrence (i.e., coronal migration of the gingival margin), the following was found: 1) 5-year follow-up: two Class I and three Class III GR (n = 5, 11.11%) displayed RD increase while just one Class I GR (2.22%) CA; 2) 10-year follow-up: four Class I and four Class III GR (n = 8, 17.78%) showed RD increase whereas three Class I GR (6.67%) CA; 3) 15-year follow-up: six Class I and six Class III GR (n = 12, 26.67%) exhibited RD increase while three Class I and one Class III GR (n = 4, 8.89%) CA; and 4) 20-year follow-up: seven Class I and six Class III GR (n = 13, 28,89%) presented RD increase whereas three Class I and one Class III (n = 4, 8.89%) CA.

Within maxillary Class I defects (Table 2), CRC at 1-year follow-up was 56.52% (n = 13) and 47.82% (n = 11) at the end of study period, whereas MRC decreased from 81.01% to 76.61%, respectively. Overall, RD significantly decreased between baseline and each evaluation, but no significant GR recurrence (RD change) was found between the different follow-ups. Also, KT significantly increased 1 year after treatment ($P < 0.05$) and no significant KT contraction was detected between the 1-year and the 5-, 10-, 15-, and 20-year assessments ($P > 0.05$). In addition, the significant PD decrease found 1-year after treatment remained stable during the course of the study ($P < 0.05$).

Within maxillary Class III recessions (Table 2), CRC of 20.83% (n = 5) was found at both the 1-year and the 20-year follow-ups. On the other hand, MRC decreased from 66.55% to 58.18%, respectively. Equally to Class I GR, Class III experienced significant RD decreased between baseline and each

TABLE 2 Clinical measurements at baseline and 1-, 5-, 10-, 15-, and 20- year follow-up: Maxillary Class I GR and Class III GR

	Class I GR		Class III GR	
	Mean; SD [95% CI]	*P* Value	Mean; SD [95% CI]	*P* Value
RD				
Baseline	2.95; 1.16 (2.42 to 3.48)	*	2.87; 0.89 (2.49 to 3.25)	*
1 year	0.52; 0.68 (0.21 to 0.8)	*	0.96; 0.62 (0.69 to 1.22)	*
5 year	0.57; 0.81 (0.20 to 0.94)	*	1.08; 0.77 (0.75 to 1.41)	*
10 years	0.57; 0.81 (0.20 to 0.94)	*	1.08; 0.83 (0.73 to 1.43)	*
15 years	0.62; 0.92 (0.19 to 1.03)	*	1.12; 0.85 (0.76 to 1.48)	*
20 years	0.66; 0.96 (0.22 to 1.10)		1.20; 0.97 (0.79 to 1.62)	
KT				
Baseline	1.71; 1.01 (1.25 to 2.17)	*	1.91; 0.97 (1.50 to 2.33)	*
1 year	2.66; 1.01 (2.20 to 3.12)	*	3.16; 0.87 (2.80 to 3.53)	*
5 years	2.71; 1.05 (2.23 to 3.19)	*	3.08; 0.88 (2.71 to 3.45)	*
10 years	2.61; 1.16 (2.09 to 3.14)	*	2.96; 0.91 (2.57 to 3.34)	*
15 years	2.47; 1.12 (1.96 to 2.98)	*	2.91; 0.93 (2.52 to 3.31)	*
20 years	2.52; 1.25 (1.95 to 3.09)		2.83; 1.01 (2.40 to 3.26)	
PD				
Baseline	1.42; 0.59 (1.15 to 1.70)		1.16; 0.38 (1.00 to 1.33)	
1 year	1.14; 0.36 (0.98 to 1.30)		1.04; 0.20 (0.95 to 1.13)	
5 years	1.19; 0.40 (1.00 to 1.37)		1.08; 0.28 (0.96 to 1.20)	
10 years	1.28; 0.46 (1.07 to 1.49)		1.16; 0.38 (1.00 to 1.33)	
15 years	1.28; 0.46 (1.07 to 1.49)		1.20; 0.41 (1.03 to 1.38)	
20 years	1.28; 0.46 (1.07 to 1.49)		1.25; 0.44 (1.06 to 1.44)	

*Statistically significant (one-way repeated measures ANOVA test followed by the Tukey test [$P < 0.05$])

evaluation, but no significant GR recurrence (RD change) was found between the different follow-ups. Also, KT significantly increased 1 year after treatment ($P < 0.05$), but significant KT contraction was identified between the 1-year and the 10-, 15-, and 20-year assessments ($P < 0.05$). Additionally, significant PD increase occurred between the 1-year and the 15- and 20-year follow-ups ($P < 0.05$).

3.2 | Logistic regression analyses

Based on the outcomes of the recent AAP Regeneration Workshop papers[2–4] and another long-term CAF study,[10] four potential predictor factors (i.e., non-smoking status, lack of interproximal tissue loss, lack of root step and baseline RD < 4 mm) were included into the regression models evaluating treatment outcomes in terms of complete root coverage 1 year after treatment (Table 3). The results of this analysis showed that the achievement of CRC was associated only to GR not presenting interdental tissue loss (i.e., Class I, OR: 5.031, $P = 0.024$).

Regarding the appraisal of GR recurrence at the different follow-up periods (i.e., 5-years versus year 1, 10-years versus year 1, 15-years versus year 1 and 20-year versus year 1 follow-ups), it was assessed using similar dependent and independent variables. The results of these analyses are depicted in Table 4, and key findings are summarized below: a) 5-year follow-up: GR recurrence was associated to sites with attached KT < 2 mm ($P = 0.036$); b) 10-year follow-up: GR recurrence was associated with teeth presenting root steps ($P = 0.039$) and attached KT < 2 mm ($P = 0.014$); c) 15-year follow-up: GR was associated with sites with smoking ($P = 0.043$) attached KT < 2 mm ($P = 0.021$); d) 20-year follow-up: GR was associated to teeth presenting root steps ($P = 0.030$) and attached KT < 2 mm ($P = 0.007$).

4 | DISCUSSION

The focus of this study was to evaluate the long-term outcomes of the bilaminar technique (CAF+SCTG) for the treatment of maxillary single gingival recessions in cases with at least 20-year follow-up. Short- and medium-term outcome studies on SCTG + CAF show that this approach can be considered the most reliable option to treat single GR.[2,13]

TABLE 3 Logistic regression: CRC at 1-year follow-up

CRC	Odds Ratio	Standard Error	z	P > |z|	95% CI	
Non-smoking	3.037	2.556	1.32	0.187	0.583	15.814
Lack of interproximal tissue loss	5.031	3.609	2.25	0.024[a]	1.233	20.524
Lack of root step	3.680	3.089	1.55	0.121	0.7102	19.070
Baseline RD < 4 mm	0.8761	0.702	−0.16	0.869	0.181	4.219
_constant	0.049	0.064	−2.30	0.021[a]	0.003	0.638

[a]Statistically significant; Binary variables: non-smoking (coded 1), lack of interproximal tissue loss (coded 1), lack of root step (coded 1), baseline RD < 4 mm (coded 1).

TABLE 4 Logistic regression: GR recurrence at 5-, 10-,15- and 20-year follow-ups

GR recurrence						
5-year follow-up	**Odds Ratio**	**Standard Error**	**z**	**P > |z|**	**95% CI**	
Smoking	14.684	23.593	1.67	0.094	0.629	342.356
Presence of interproximal tissue loss	2.704	3.530	0.76	0.445	0.211	34.667
Presence of root step	3.753	5.421	0.92	0.360	0.221	63.665
Attached KT < 2 mm	23.620	35.704	2.09	0.036[a]	1.220	457.038
_constant	0.005	0.103	−2.63	0.008	0.000	0.259
10-year follow-up						
Smoking	4.297	5.791	1.08	0.279	0.306	60.297
Presence of interproximal tissue loss	0.851	0.814	−0.17	0.867	0.130	5.553
Presence of root step	13.517	917.013	2.07	0.039[a]	1.146	159.317
Attached KT < 2 mm	32.154	45.433	2.46	0.014[a]	2.016	512.805
_constant	0.007	0.011	−3.11	0.002[a]	0.000	0.162
15-year follow-up						
Smoking	10.057	11.468	2.02	0.043[a]	1.076	93.999
Presence of interproximal tissue loss	0.887	0.708	−0.15	0.882	0.185	4.240
Presence of root step	7.257	7.545	1.91	0.057	0.945	55.689
Attached KT < 2 mm	9.604	9.442	2.30	0.021[a]	1.398	65.962
_constant	0.035	0.040	−2.90	0.004[a]	0.003	0.338
20-year follow-up						
Smoking	18.820	29.361	1.95	0.051	0.981	360878
Presence of interproximal tissue loss	1.101	0.932	0.11	0.909	0.209	5.785
Presence of root step	17.030	22.237	2.17	0.030[a]	1.317	220.137
Attached KT < 2 mm	33.797	44.347	2.68	0.007[a]	2.582	442.384
_constant	0.011	0.017	−2.92	0.004[a]	0.000	0.229

[a]Statistically significant; binary variables: smoking (coded 1), presence of interproximal tissue loss (coded 1), presence of root step (coded 1), attached KT < 2 mm (coded 1).

Conversely, there is scarce evidence on long-term results (i.e., >5 years follow-up).[2] For instance, the Consensus Report of European Workshop on Periodontology strongly advises that long-term results with at least 5 years of follow-up are generally needed to evaluate the stability of the clinical outcomes.[7]This clinical study is the first one to present the 20-year outcomesof SCTG + CAF (Figures 1A through 1F), as well as to explore the potential influence of some patient- and tooth-related factors on GR recurrence. Similar to the findings of AAP Regeneration Workshop papers,[2–4] it could be demonstrated that MRC achieved 1 year after surgery decreased over time, independently of the type of GR (i.e., Class I or Class III). Besides, a similar trend was observed considering CRC at 1 year and at the end of the 20-year follow-up period. Concerning Class I GR these achieved greater CRC than Class III at short-term. These findings are in line with data from Pini Prato et al.[10] that noticed similar MRC and CRC findings following the 20-year evaluation on GR treated by CAF. On the other hand, the number of Class III GR that achieved CRC at the 1-year follow-up remained stable during the study period whereas CRC decreased at Class I/II recessions.

In terms of GR recurrence and occurrence of CA, the outcomes of this long-term study showed that the level

of the gingival margin does not seem stable during the follow-up period: indubitably different treated sites showed an apical shift of the margin between the 5 and 20 years ranging from 11.11% to 28.89%, respectively. Of the 21 Class I GR included in the study, 33.33% (n = 7) exhibited some degree of GR recurrence after 20 years whereas six of the 24 Class III defects (25%) showed similar outcome. Conversely, few sites showed a coronal shift of the margin (i.e., CA) from 2.22% at 5 years to 8.98% at 20 years. Overall, 14.28% (n = 3) of the Class I recessions displayed CA (Figures 2A through 2F) while just 4.16% (n = 1) of Class III GR exhibited the same phenomenon. By comparing such outcomes with the data of two recent long-term studies on soft tissue augmentation procedures, these seem to agree with data from Agudio et al.[9] (i.e., free gingival grafts) but not with the findings reported by Pini Prato et al.[10] (i.e. CAF). In the first study,[9] the authors stated, "that an ongoing coronal migration of the GM could be noted not only during the first phase of follow-up (6 to 12 months), but through subsequent long-term periods of time". In this study, CA was more evident after 5 years of follow-up. In contrast, as demonstrated previously,[10] none of the 72 GR treated by CAF alone showed creeping attachment 20 years after treatment. Therefore, based on the overall outcomes reported by previous investigations[9,10] and this study, it might be demonstrated that the occurrence of CA seems more prone to occur at sites submitted to soft tissue augmentation by graft-based than flap-based procedures. Conversely, it remains unclear how, when and which specific conditions (i.e., local, systemic, or surgical) could trigger this phenomenon.

Moreover, it seems critical to highlight the impact of different site- and patient-related factors in terms of treatment predictability and stability. Outcomes drawn by the logistic regression analysis evaluating the impact of four of these potential predictor factors confirmed the importance of interproximal tissue on the achievement of CRC 1 year after treatment (Table 2). Similar to previous clinical and review studies,[2,5,10,11,14] the present study confirmed that Class I GR are more prone to achieve CRC (OR: 5.031, $P = 0.024$). Likewise, inferential statistics clearly demonstrated that the apical shift of the gingival margin between the 5 and 20 years assessments seemed to be associated with teeth presenting root steps/NCCL, smoking and attached KT < 2 mm ($P < 0.05$). It could be argued that mean KT increase 1 year after treatment (0.95 mm for Class I GR and 1.21 mm for Class III GR) may not reflect clinically significant improvements. This assumption might be considered true for those sites presenting an attached KT ≥ 2 mm before surgery. On the other hand, it should be noted that for those GR lacking a minimum attached KT width of 2 mm before treatment, these "small" KT gains might have promoted more gingival margin stability over the 20-year follow-up period.

It should be also emphasized that the observed recession recurrence could be attributable to the resumption of traumatic toothbrushing habits by patients with high level of oral hygiene (FMPS < 20%) even if they were enrolled in a stringent maintenance protocol with recalls every 4 to 6 months as well.

Conversely to the findings of some previous publications,[2,15] it could not be demonstrated that the influence of smoking and baseline RD on the achievement of CRC 1 year after treatment (smoking and baseline RD) as well as only the 15-year follow-up indicated that smoking might have a direct impact on GR recurrence. With respect to smoking, evidence is clear that it may decrease both MRC (I.e., -17.50%) and the number of sites achieving CRC (i.e., -36.00%) when SCTG + CAF is the treatment of choice of Class I GR.[2] Differences between the current outcomes and those available in the literature might be explained by different conditions: 1) the restricted number of smokers included in the study (n = 12) compared with those reported by preceding reviews;[2,15] 2) the lack of information on the number of cigarettes smoked per day (previous reviews evaluated only patients who smoked ≥10 per day); and 3) previous comparisons[2,15] were based on MRC (i.e., recession change) by ''head-to-head'' (pairwise) meta-analyses evaluating outcomes versus non-smokers while this study used logistic regression assessments. Regarding the lack of influence of baseline RD on the accomplishment of CRC after treatment, it should be noted that only eight Class I and five Class III GR (n = 13, 28.88%) presenting RD ≥ 4 mm were included in the logistic regression model. Preceding investigations conducted using Bayesian network[13,16] and mixed-effects logistic regression[17] statistics indicated that the greater the baseline RD, the smaller the chance of achieving CRC. It should be also acknowledged that both analyses were conducted with data exclusively from Class I and II GR, and with a superior number of defects (i.e., one of the studies included 602 recessions[17]). Overall, there is clear indication that "statistically significant differences (e.g., $P < 0.05$) are more likely to be detected with large sample sizes compared with small ones."[18]

It could be argued that the aging process might have an impact on the development of GR.[10] Unfortunately, it was opted not to include this factor in the statistical model because the number of GR available in the study didn't allow the inclusion of >4 independent variables into the regression model. It has been suggested that potential changes associated with the aging process could be explained by a decline in immune functions (i.e., immune senescence), changes in neutrophil function and augmented production of different proinflammatory mediators as well.[19] Likewise, it should be considered that: 1) during the 20 years of observation patients' compliance should have played an important role in the

maintenance of the results achieved at short-term in view of the potential maintenance of adequate oral hygiene levels and correction of eventual traumatic toothbrushing habits over the course of the study; 2) through the seven years (1990 to 1997) the patients received their treatment, the operator skills improved and this learning curve might have also influenced the 1-year outcomes; and 3) improvements on instrumental sets and surgical techniques during the period may have gradually improved the initial technique and the outcomes achieved with therapy. All of these conditions probably introduced some heterogeneity in the original intervention protocol, but these issues *per se* reflect the natural course of clinical practice and therefore allow interpretation of the results in the context of "real world" treatment outcomes. Furthermore, it's important to contemplate that subsequent studies reporting modifications of bilaminar technique, such as the graft thickness, graft position on the exposed root surface,[20] new flap designs,[21,22] and the use of microsurgical equipment/instruments[23] contributed to improve the short-/medium-term outcomes of CAF-based procedures; however, long-term results for these technical/surgical modifications are still lacking.

In addition, it should be pointed out that the unusual wide confidence intervals for some odds ratios might be associated with potential inherent stabilities of the regression model because of a "relative" small sample of patients (n = 45) available for this 20-year assessment, as well as to some degree of multicollinearity (i.e., when one of the predictors is linearly related with other predictors).[24] These assumptions may not allow the accomplishment of ultimate conclusions on the potential predictors influencing GR recurrence, however the findings of the present study are in line with data from the clinical evidence available in the literature.[2–4,6,8–11]

5 | CONCLUSIONS

Within the limits of this clinical study, it can be concluded that most of the positive RD and KT improvements achieved by SCTG + CAF at short-term may be preserved long-term. Teeth lacking a minimal 2 mm width of attached KT and presenting NCCL were more prone to develop an apical shift of the gingival margin (i.e., GR recurrence) over the course of the study. Overall, patients dysplaying high standards of oral hygiene/dental biofim control with single GR treated by SCTG + CAF could be maintained for a 20-year follow-up period, with the majority of these sites (2/3 or ≈70%) without any apical shift of the gingival margin.

ACKNOWLEDGMENT

The authors report no conflicts of interest related to this study.

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How to cite this article: Pini Prato GP, Franceschi D, Cortellini P, Chambrone L. Long-term evaluation (20 years) of the outcomes of subepithelial connective tissue graft plus coronally advanced flap in the treatment of maxillary single recession-type defects. *J Periodontol*. 2018;89:1290–1299. https://doi.org/10.1002/JPER.17-0619