

**CASE SERIES**

The influence of tooth location on the outcomes of multiple adjacent gingival recessions treated with coronally advanced flap: A multicenter re-analysis study

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Abstract

Background: Tooth location has been shown to play a significant role on root coverage outcomes. However, whether this has an impact on the outcomes of coronally advanced flap (CAF) for treating multiple adjacent gingival recessions (MAGRs) remains to be determined. The aim of this study was to investigate the impact of tooth location, flap design, and flap extension on the outcomes of MAGRs following CAF with or without a connective tissue graft (CTG).

Methods: A re-analysis of six previously published clinical trials evaluating the outcomes of CAF in the treatment of MAGRs was performed using mixed regression and logistics to assess the influence of potentially influential factors on the treatment outcomes.

Results: Six hundred and nine MAGRs in 166 patients were evaluated. The anterior maxilla (second sextant) was associated to the highest mean root coverage (mRC) and complete root coverage (CRC) outcome ($P < 0.05$). In addition, the maxillary teeth showed significantly greater mRC and CRC than teeth in the mandible (with the lower anterior [fifth sextant] showing the lowest outcomes) ($P < 0.05$). A higher mRC was observed for the anterior teeth compared with posterior dentition ($P < 0.05$). While CAF + CTG achieved better results than CAF alone, no differences were found when the flap was performed with or without vertical releasing incisions ($P > 0.05$). Lastly, teeth in the distal part of the flap showed lower mRC and CRC than teeth in the central or mesial position ($P < 0.05$).

Conclusions: Tooth location was found to play a key role in determining the amount of root coverage achievable, with maxillary canines and incisors being associated with the highest outcomes compared with other sextants. Maxillary MAGRs showed greater mRC and CRC than mandibular MAGRs.

KEYWORDS

dental esthetics, evidence-based dentistry, gingival recession, surgical flaps, tooth root



1 | INTRODUCTION

Gingival recession (GR) is a common finding among most adult patients. This condition is clinically manifested by an apical shift of the gingival margin in respect to the cemento-enamel junction (CEJ) that leaves a portion of the root surface exposed and may lead to root caries or abrasion, esthetic concerns as well as dental hypersensitivity.¹⁻⁴ It has been estimated that 58% of adults in the United States have a GR ≥ 1 mm,⁵ which seems to increase with age and in males.^{2,5-7} In addition, smoking and presence of supragingival calculus were found to be significant risk indicators of localized and generalized GRs.²

Despite the fact that GR is most often a generalized condition rather than being localized to a single tooth,^{4,8,9} most of the data currently in the literature pertains to treatment of localized GRs. While several reviews and meta-analyses have been performed to evaluate the most effective approaches for treating single GRs,¹⁰⁻¹² evidence regarding the efficacy of periodontal plastic surgery in treating multiple adjacent gingival recessions (MAGRs) is scarce.^{13,14} It has been suggested that MAGRs should be treated concurrently for minimizing patient discomfort.^{4,8,9} Additionally, their treatment may pose more challenges compared with localized GRs due the more likely encounter of anatomical factors (such as shallow vestibule, root prominence, and limited keratinized tissue width [KTW])^{14,15} that need to be taken into consideration.

Bernimoulin and co-workers were the first to describe a treatment approach for treating MAGRs, which included a free gingival graft followed by a coronally positioned flap two months after.¹⁶ Later on, Zucchelli and De Sanctis⁸ introduced a new flap design for MAGRs in the esthetic zone, which involved an envelope coronally advanced flap (eCAF) that anticipates the rotational movement of the surgical papillae during its coronal advancement. This technique includes a split-full-split approach during flap elevation as well as with a superficial and deep dissection for obtaining a tension-free flap. This approach is able to reduce the damage to the vasculature supply, provide a better marginal soft tissue adaptation and minimize the risk of keloid formation, when compared with the traditional CAF.^{8,17,18}

The CAF and the tunnel technique are the two main approaches that have been described for treating MAGRs.¹⁵ According to a recent meta-analysis, the CAF was able to yield superior outcomes in terms of complete root coverage (CRC) than the tunnel approach.¹⁹ The CAF for the treatment of MAGRs has been performed with either two vertical releasing incisions or an envelope approach,^{18,20} with oblique or horizontal incisions at the papillae,²¹ alone or with the addition of a connective tissue graft (CTG)^{22,23} or substitute materials.^{9,24}

The influence of tooth location on root coverage outcomes has been frequently suggested by several clinicians^{17,25,26} and recently, Zucchelli and coworkers have demonstrated that the tooth site plays a role in determining the mean root coverage (mRC) and the CRC following CAF for localized GR.²⁷ However, the impact of tooth location on CAF in the treatment of MAGRs has not yet been extensively explored. Aroca et al. observed the best results in terms of mRC were obtained in the anterior maxilla, while the maxillary molars showed the worst outcomes.²⁸ Additionally, when performing CAF for MAGRs, other factors, that have not been investigated yet, such as flap design (with or without vertical releasing incisions), flap extension and position of the tooth with respect to the flap (in the center, in the mesial or distal end) may also affect the outcomes of the soft tissue coverage.

Given the limited data available in the literature, we conducted a multi-center re-analysis study, a research design already explored in several medical fields for increasing the sample size with individual patient data (IPD).²⁹⁻³¹ Therefore, the aim of this study was to investigate the impact of tooth location, flap design, and flap extension on the outcomes of MAGRs following CAF with or without a CTG.

2 | MATERIALS AND METHODS

2.1 | Study design and inclusion criteria

The study was designed as a multicenter re-analysis study involving the following six centers: University of Bologna, Italy; University of Milan, Italy; a private practice in Bologna, Italy; a private practice in Florence, Italy; Universitat Internacional de Catalunya, Barcelona, Spain; and the University of Michigan, Ann Arbor, USA.

The IPD of six previous published trials were screened for eligibility^{9,18,23,32-34} (see supplementary Data S1 file in the online *Journal of Periodontology*), and patients were included if they received CAF with or without a CTG for the treatment of MAGRs and were continuously followed for at least a duration of 6 months. The IPD was excluded from the data analysis if any graft material different than a CTG, were used (e.g., collagen matrix, acellular dermal matrix or biologics).

All relevant data regarding the patient characteristics such as age, sex, smoking habits, the medical history, flap design (with or without vertical incisions), flap extension, and tooth location were recorded. The following measurements were collected at the baseline and at the follow-up: recession depth (REC), probing depth (PD), clinical attachment level (CAL), and KTW. IPD were gathered by an examiner who was not involved in the surgical procedures (LT).

The primary outcome of the study was the influence of tooth location on the mRC and CRC for each sextant (first:



right maxilla, second: anterior maxilla, third: left maxilla, fourth: left mandible, fifth: lower anterior, and sixth: right mandible). The secondary outcomes of the study include: the impact of flap design and extension on the outcomes, the center-effect, CAL gain, KTW change, and the comparison between CAF with or without CTG.

All patients had provided written informed consent to the surgical procedure. This study protocol was in accordance with the Helsinki Declaration of 1975, as revised in 2000. The IPD were collected from previous clinical trials, all of which were also performed in full according with the ethical principles of the Declaration of Helsinki and received primary ethical approval from the competent local authority (Institutional Review Board) for each center as well.

2.2 | Intervention

MAGRs were treated with an envelope (eCAF)⁸ (Figs. 1 and 2) or with two vertical releasing incisions (vCAF)¹⁸ (Fig. 3). In addition, according to the study protocol, CTG was added in some cases over ≥ 1 root surface(s). The flap was then coronally advanced and sutured. Subjects were followed for at least a 6-month period.

2.3 | Outcomes

The primary outcomes of interest were the mRC and CRC per sextant and according to the location of the jaw (mandibular and maxillary arch).

The secondary outcomes were evaluation of the possible influence of flap design (whether eCAF or vCAF), and the position of the tooth in the flap itself (whether at the distal end, in the middle, or at the mesial end) and its impact on root coverage outcomes.

2.4 | Data analysis

All analyses were performed by an author with expertise in statistical analyses (SB) who was not involved in the surgical procedures and was masked to the raw primary patient data. The lme4 package³⁵ was used to create mixed linear regression models for continuous data (mRC, baseline REC, keratinized mucosa), and mixed logistics models for the binary outcomes (CRC). We controlled for the center effect (multiple patients treated within a particular center/study), and the patient effect (multiple teeth treated in the same patient), by adjusting the fixed effects for articles, and random effects for patients within an article. Other possible influential variables such as baseline characteristics (REC at baseline, and amount of keratinized mucosa) were also included in the model and tested via different interactions. Lastly a *P* value threshold

of 0.05 was set for statistical significance for the multi-study analyses.

3 | RESULTS

Six hundred and nine MAGRs were treated in 166 patients (102 females and 64 males, mean age 38.5 ± 8.6 years). Among these, the CAF was performed for treatment of 321 MAGRs, while the CAF + CTG was the approach used in 288 MAGRs. The mean follow-up duration was 11 ± 2.2 months.

3.1 | Effect of tooth location on mean and complete root coverage following CAF

The overall mRC and CRC following CAF were $87.4\% \pm 18.7\%$ and 63.1% , respectively. The highest mRC and CRC ($94.8\% \pm 10.6\%$ and 79.2%) were found for teeth treated in the second sextant, while significantly lower coverages were observed for the fourth, fifth, and sixth sextants (Table 1). When the first sextant served as the reference, the second sextant was related to a significantly higher mRC ($P < 0.001$) and CRC ($P < 0.001$), while the fourth, fifth, and sixth sextants showed significantly lower mRC outcomes ($P < 0.01$) (Table 1).

Maxillary MAGRs were associated with a significant greater mRC than mandibular MAGRs ($89.7\% \pm 16.7\%$ versus $67.1\% \pm 22.7\%$, $P < 0.001$). Similarly, CRC was found to be higher in maxillary MAGRs than mandibular MAGRs (67% versus 25% , $P < 0.001$).

No significant differences were found when right and left sides were compared for mRC and CRC outcomes ($P > 0.05$), while anterior teeth (second and fifth sextants) showed greater mRC and CRC than posterior teeth (first, third, fourth, and sixth sextants) ($P < 0.001$).

3.2 | Effect of tooth location on mean and complete root coverage following CAF+CTG

The overall mRC and CRC following CAF+CTG were $94.13\% \pm 12.7\%$ and 78.9% , respectively. The highest mRC and CRC ($97.4\% \pm 7.9\%$ and 89.7%) were found for the second sextant, while the fifth sextant showed the lowest mRC ($88.6\% \pm 21.1\%$) and teeth in the sixth sextant revealed the lowest CRC (59%) (Table 1).

When the first sextant was set as the reference, only the fifth sextant showed a significantly lower mRC ($P < 0.05$) and CRC ($P < 0.05$).

Maxillary MAGRs presented a greater mRC than mandibular MAGRs ($95.8\% \pm 10.3\%$ versus $90.5\% \pm 16.4\%$, $P < 0.001$). Similarly, CRC was found to be higher in the maxillary MAGRs than mandibular MAGRs (84% versus 62% , $P < 0.001$).



FIGURE 1 Maxillary multiple adjacent gingival recessions treated with envelope coronally advanced flap. (A) Baseline; (B) Flap design; (C) 1-year outcomes



FIGURE 2 Maxillary multiple adjacent gingival recessions treated with envelope coronally advanced flap and a connective tissue graft. (A) Baseline; (B) Flap design; (C) 1-year outcomes

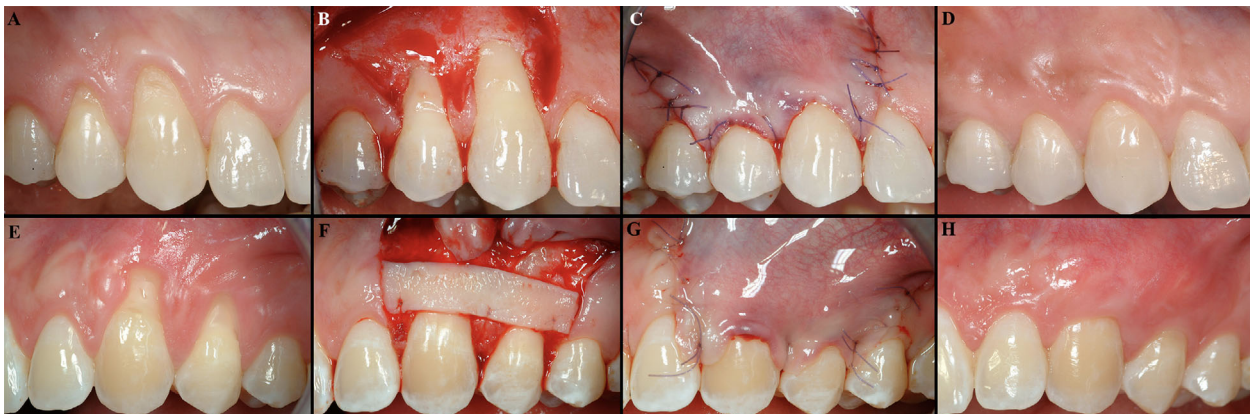


FIGURE 3 Maxillary multiple adjacent gingival recessions treated with coronally advanced flap with two vertical releasing incisions. (A) Baseline; (B) Flap design; (C) Postoperative photo showing the closure by primary intention, and (D) 1-year outcomes. (E) Baseline; (F) A connective tissue graft was positioned and sutured over the root of the canine and the premolar; (G) Postoperative photo showing the closure by primary intention; (H) 1-year outcomes

TABLE 1 Outcomes of MAGRs treated with CAF and CAF + CTG divided by sextant

Sextant	CAF			CAF+CTG		
	n (sites)	mRC (%)	CRC (%)	n (sites)	mRC	CRC
1	60	86.1 ± 18	56.6	34	92.2 ± 15.3	76.5
2	154	94.8 ± 10.6	79.2	91	97.4 ± 7.9	89.7
3	74	81.9 ± 21.8	51.4 ^a	62	95.5 ± 9.4	79.3
4	15	74.4 ± 26.8 ^a	49.7	36	90.9 ± 13.7	64.3
5	5	58.3 ± 9.6 ^a	25 ^a	35	88.6 ± 21.1	61.3
6	13	61.2 ± 18.3 ^a	38.5 ^a	30	92.7 ± 11.8	59.1

Sextants description: First: right maxilla; second: anterior maxilla; third: left maxilla; fourth: left mandible; fifth: lower anterior, and sixth: right mandible.

^aSignifies that the comparison between the CAF and CAF+CTG approach in the particular sextant reached statistical significance

**TABLE 2** Regression analysis on potential factors affecting the mean root coverage outcome on multiple adjacent gingival recessions

Treatment group	Parameter (reference)	Coefficient (95% CI)	P value
CAF	Age	-0.12 (-0.42 to 0.18)	0.43
	Smoking	2.68 (-11.56 to 16.61)	0.71
	Vertical releasing incisions	-2.28 (-9.64 to 5.09)	0.54
	Arch (maxilla)	4.86 (2.4 to 7.3)	<0.001
	Anterior versus posterior (posterior)	-3.76 (-6.02 to -1.5)	<0.001
CAF + CTG	Age	-0.19 (-0.56 to 0.18)	0.56
	Smoking	2.06 (-2.42 to 6.54)	0.58
	Vertical releasing incisions	-1.04 (-3.02 to 0.94)	0.35
	Arch (maxilla)	3.2 (-0.54 to 6.94)	<0.001
	Anterior versus posterior (posterior)	-1.52 (-4.7 to 1.65)	0.34

No significant differences were found when the right and left sides were compared for mRC and CRC outcomes ($P > 0.05$), and among anterior (second and fifth sextants) and posterior teeth (first, third, fourth, and sixth sextants) in terms of mRC ($P > 0.05$). However, anterior teeth showed a higher CRC when compared with posterior teeth (82.2% versus 72.3%, $P < 0.05$).

3.3 | Flap design (with or without vertical incisions)

The mRC of sites treated with vCAF and eCAF were found to be $86.4 \pm 20.5\%$ and $87.6 \pm 18.4\%$, respectively. Similarly, no differences were found for the outcome of CRC (60% versus 63.6%, $P > 0.05$).

The mRC of vCAF + CTG and eCAF + CTG were $86.5 \pm 25.8\%$ and $94.7 \pm 11.3\%$, respectively and the CRC was found to be 62.5% for vCAF + CTG and 77.82% for eCAF + CTG. However, this difference was not statistically significant ($P > 0.05$).

3.4 | Tooth position in the flap

When treatment with CAF alone was considered, the teeth in the center of the flap showed the greatest mRC ($92.4\% \pm 15.4\%$) and CRC (76.7%), compared with teeth in the mesial position of the flap (mRC $92\% \pm 13.1\%$, CRC 69.7%) and teeth in the distal position (mRC $77.2\% \pm 22.3\%$, CRC 40.2%). When the center position in the flap was set as the reference, the treated teeth in the distal position was found to be related to a statistically significant lower mRC and CRC ($P < 0.001$), with no differences between the center and mesial position ($P > 0.05$).

On the other hand, in the CAF + CTG group, teeth in the center of the flap showed the greatest mRC ($97.4\% \pm 8\%$) and CRC (88.7%), compared with the teeth in the mesial position (mRC $92.3\% \pm 15.2\%$, CRC 74.1%) and teeth in the distal position (mRC $90.1\% \pm 14.4\%$, CRC 74.1%). When center position in the flap served as the reference, the distal position

was found to have a statistically significant lower mRC and CRC ($P < 0.001$) while no differences were observed between the center and mesial position ($P > 0.05$).

3.5 | Regression analysis

Multivariate regression analysis accounting for potential confounding variables such as the type of procedure performed (CAF alone or CAF + CTG), flap design (with or without vertical incisions) and tooth location (maxilla versus mandible and anterior versus posterior region) failed to detect a significant effect of age, smoking, center effect, and follow-up on the mRC (P values of 0.47, 0.81, 0.18, 0.09 for mRC, and 0.09, 0.42, 0.95, 0.28, 0.19 for CRC, respectively) (Table 2).

4 | DISCUSSION

The occurrence of MAGRs is not a rare clinical finding. However, little is known regarding the predictability of its treatment with the CAF, and whether or not and to what extent factors such as tooth location, flap design, and tooth position and location in the flap have an impact on the amount of root coverage that can be attained. Previous systematic reviews on this topic have been inconclusive in resolving these crucial clinical questions.^{14,36} Therefore, we designed this multicenter study according to methodologies previously presented in medicine to increase our sample size by pooling IPD (from prior clinical studies) and to significantly extend our power of analysis to explore factors never before investigated in the literature, particularly to this extent.²⁹⁻³¹

The results of our analyses demonstrated that CAF, with or without a CTG, is an effective procedure for the treatment of MAGRs, and that the amount of recession reduction is affected by the tooth location. In agreement with previous studies,^{22,23} the addition of CTG was able to enhance the outcomes of CAF ($94.13\% \pm 12.7\%$ versus $87.4\% \pm 18.7\%$ for mRC; and 78.9% versus 63.1% for CRC). Among the advantages of CTG compared with treatment with flap alone, it has



been speculated that the CTG acts as a biological scaffold that enhances flap adaptation to the root surface,²² providing added increased soft tissue thickness³⁷ which has been correlated with higher CRC³⁸ and long-term stability.^{39,40}

A recent article from our group has corroborated the importance of tooth location in CAF for isolated GRs, reporting that canines and incisors were related to a higher mRC and CRC than posterior teeth.²⁷ The present study confirms these findings also when CAF is performed for MAGRs. In particular, the second sextant showed the greatest mRC and CRC in both CAF and CAF + CTG groups compared with the other sextants. A possible explanation may be the unfavorable anatomic conditions such as marginal frenulum, high muscle pull, higher flap tension, and shallow vestibule that are frequently encountered in the mandibular incisors area, as compared with their rare occurrence in the maxillary anterior region.^{4,27} These conditions may negatively impact root coverage outcomes.⁴¹ In addition, mRC and CRC were found to be significantly higher in maxillary MAGRs compared with mandibular MAGRs. Previous investigations suggest that lower outcomes should be expected when treating mandibular GRs.^{25,26,42} Indeed, as suggested by Aroca et al., the smaller dimension of the papillae, along with the pull from the lip muscles and the shallow vestibular depth, may account for the lower predictability of treating GRs in the mandible compared with the maxilla.²⁶

An interesting finding from the present study was the influence of tooth position in relation to the flap (whether vCAF or eCAF) on the amount of root coverage. The treated teeth in the distal part of the flap showed lower mRC and CRC than ones in the central and mesial portion of the flap, whether with the eCAF or the vCAF. The importance of flap design in root coverage procedures has been advocated by several authors.^{17,43} While performing two vertical releasing incisions can increase flap mobilization by 124.2% of its original length,⁴⁴ in an angiographic study evaluating the tropism of flaps with different design, Mörman and Ciancio observed a reduced revascularization when vertical incisions were performed.⁴⁵ The eCAF was introduced for the treatment of MAGRs to avoid the vertical incisions which may impair vascular supply to the flap in its lateral part, and reduce the risk of keloid formation.²⁰ However, the lack of vertical releasing incisions may pose a challenge in achieving a tension-free flap, one of the main key factors in periodontal plastic surgery and in bone regeneration.^{17,43,46} In addition, other anatomical conditions including root prominence, limited KTW and reduced vestibule depth, which are commonly found in posterior areas^{17,41,47} may also negatively affect the predictability of root coverage procedures.^{17,27} These speculations may explain the lower outcomes observed for teeth in the distal part of the flap, both in the eCAF and vCAF design, regardless adding a CTG. In line with our findings, a recent clinical trial found that vertical incisions did not affect

clinical and esthetic outcomes of MAGRs treated with CAF + CTG.²⁰ As suggested by Sanz and Simion,⁴⁸ it may be concluded that although the choice of flap design depends on the GR depth, location, and number of teeth involved, avoiding vertical releasing incisions should be recommended to reduce the damage to the blood supply.⁴⁸ In addition, as the envelope flap is considered more minimally invasive than the traditional trapezoidal flap⁴³ this could also lead to reduced postoperative morbidity.¹⁸

Although a center effect has been reported in previous investigations,^{9,49} our analyses did not show differences among the centers in terms of mRC and CRC. A possible reason may be that the patients included in the present study were treated with flap designs, either the eCAF or the vCAF, that have been previously well described and established in the literature, thus decreasing the necessity for a priori calibration among the surgeons.^{8,18} Furthermore, we used a statistical methodology that controlled for the potential heterogeneity of different operators/centers for every model, hence the regression analyses demonstrate the mere effect of different treatments (e.g., CAF, CAF+CTG, etc) on the variables of interest (e.g., tooth location, vertical incisions, etc).

The importance of gingival thickness has been related to determining whether a CTG is needed^{32,50} as well as its influence on achieving a CRC.^{25,51} However, as a limitation of the present study, it has to be mentioned that due to the insufficient information available regarding this aspect, the influence of gingival thickness was not considered in our analyses. Additionally, the IPD provided by one of the centers (accounting to a total of 45 MAGRs) was from a controlled trial, which unlike other included studies, was not randomized. Lastly, despite many studies showing that the outcomes of root coverage procedures are stable from 6 months to 1 year,^{22,52,53} the follow-up duration of all but two of the included trials was 6 months versus 1 year which was the final follow-up of the rest of the included studies.

5 | CONCLUSIONS

Within the limitations of the present study, several conclusions can be drawn: (1) tooth location can play a key role in determining the amount of root coverage achievable, with maxillary canines and incisors being associated with the highest outcomes compared with the other sextants; (2) maxillary MAGRs displayed a greater mRC and CRC post-treatment than mandibular MAGRs; (3) The CAF is an effective procedure in the treatment of MAGRs and the addition of a CTG can increase the outcome of mRC, and CRC; (4) no differences were observed between vertical releasing CAF and envelop CAF, whether with or without a CTG; and (5) teeth in the distal part of the flap are related to



significantly lower outcomes than teeth in the mesial and central part.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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