The Influence of Tooth Location on The Outcomes of Multiple Adjacent Gingival Recessions Treated with Coronally Advanced Flap: A Multicenter Re-Analysis Study

Giovanni Zucchelli[*1], DDS, PhD, Lorenzo Tavelli†[1], DDS, Shayan Barootchi†, DMD,

Martina Stefanini[*], DDS, PhD, Giulio Rasperini‡, DDS, Cristina Valles§, DDS, PhD,

José Nart§, DDS, PhD, Hom-Lay Wang†, DDS, MS, PhD

* Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy

† Department of Periodontics & Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, MI, USA

‡ University of Milan, Department of Biomedical, Surgical and Dental Sciences, Foundation IRCCS Ca' Granda Polyclinic, Milan, Italy

§ Department of Periodontology, School of Dentistry, Universitat International de Catalunya, Barcelona, Spain

[1] Contributed equally to this study

Corresponding author:

Hom-Lay Wang, DDS, MSD, PhD
Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry
1011 North University Avenue
Ann Arbor, Michigan 48109-1078, USA.
E-mail address: homlay@umich.edu

3269 **Words**; 3 **Figures**; 2 **Tables**; 53 **References**

Running title: Influence of tooth location on multiple gingival recessions

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1002/JPER.18-0732.

One sentence Summary: Tooth location plays an important role when coronally advanced flap is performed for the treatment of multiple adjacent gingival recessions

Key findings: The outcomes of coronally advanced flap for the treatment of multiple adjacent gingival recessions is strongly influenced by tooth location, with maxillary incisors and canines showing the greatest percentage of root coverage

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).

Material and Methods. A re-analysis of 6 previously published clinical trials evaluating the outcomes of CAF in the treatment of MAGRs was performed utilizing 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 (2^{nd} 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 lower jaw [with the lower anterior (5^{th} sextant) showing the lowest outcomes] ($p<0.05$). A higher mRC was observed for the anterior teeth compared to 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 to other sextants. Maxillary MAGRs showed greater mRC and CRC than mandibular MAGRs.

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

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 cementoenamel 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 to 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 & De Sanctis [8] 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 to

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 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 mean root coverage (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 [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. Material and Methods

2.1 Study design and inclusion criteria

The study was designed as a multicenter re-analysis study involving the following 6 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 individual patient data (IPD) of 6 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 individual patient data 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), KTW. IPD were gathered by an examiner who was not involved in the surgical procedures (L.T.).

The primary outcome of the study was the influence of tooth location on the mRC and CRC for each sextant (1^{st}: right maxilla; 2^{nd}: anterior maxilla; 3^{rd}: left maxilla; 4^{th}: left mandible; 5^{th}: lower anterior and 6^{th}: 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 had a primary ethical approval by the competent local authority (Institutional Review Board) for each center as well.

2.2 Intervention

MAGRs were treated with an envelope (eCAF)[8] (Figures 1 and 2) or with two vertical releasing incisions (vCAF)[18] (Figure 3). In addition, according to the study protocol, CTG was added in some cases over one or more 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 (S.B.) who was not involved in the surgical procedures and was blinded to the raw primary patient data. The lme4 package [35] was used to create mixed linear regression models for continuous data (mRC, baseline recession depth, 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 (recession depth 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 The effect of tooth location on Mean and Complete Root Coverage following CAF

The overall mRC and CRC following CAF were 87.4 ± 18.7 % and 63.1%, respectively. The highest mRC and CRC (94.8 ± 10.6 and 79.2%) were found for teeth treated in the 2nd sextant, while significantly lower coverages were observed for the 4th, 5th and 6th sextants (Table 1). When the 1st sextant served as the reference, the 2nd sextant was related to a significantly higher mRC ($p<0.001$) and CRC ($p<0.001$), while the 4th, 5th and 6th 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 ± 16.7% vs 67.1 ± 22.7%, $p<0.001$). Similarly, CRC was found to be higher in maxillary MAGRs than mandibular MAGRs (67% vs 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 (2nd and 5th sextants) showed greater mRC and CRC than posterior teeth (1st, 3 th, 4th and 6th sextants) ($p<0.001$).

3.2 The effect of tooth location on Mean and Complete Root Coverage following CAF+CTG

The overall mRC and CRC following CAF+CTG were 94.13 ± 12.7 % and 78.9, respectively. The highest mRC and CRC (97.4 ± 7.9 and 89.7%) were found for the 2nd sextant, while the 5th sextant

showed the lowest mRC (88.6± 21.1%) and teeth in the 6th sextant revealed the lowest CRC (59%) (Table 1).

When the 1st sextant was set as the reference, only the 5th 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 ± 10.3% vs 90.5 ± 16.4%, $p<0.001$). Similarly, CRC was found to be higher in the maxillary MAGRs than mandibular MAGRs (84% vs 62%, $p< 0.001$).

No significant differences were found when the right and left sides were compared for mRC and CRC outcomes ($p> 0.05$), and among anterior (2th and 5th sextants) and posterior teeth (1th, 3 th, 4th and 6th sextants) in terms of mRC ($p>0.05$). However, anterior teeth showed a higher CRC when compared to posterior teeth (82.2% vs 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 ± 20.5% and 87.6 ± 18.4%, respectively. Similarly, no differences were found for the outcome of CRC (60% vs 63.6%, $p>0.05$).

The mRC of vCAF + CTG and eCAF + CTG were 86.5 ± 25.8% and 94.7 ± 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 ± 15.4%) and CRC (76.7%), compared to teeth in the mesial position of the flap (mRC 92 ± 13.1%, CRC 69.7%) and teeth in the distal position (mRC 77.2 ± 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 to 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 taking 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 vs mandible and anterior vs 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).

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 in order to increase our sample size by pooling individual patient data (from prior clinical studies) and 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 a CTG was able to enhance the outcomes of CAF (94.13 ± 12.7 % vs 87.4 ± 18.7 % for mRC; and 78.9% vs 63.1% for CRC). Among the advantages of a CTG compared to 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 thickness [37] which has been correlated with higher CRC [38] 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 finding also when CAF is performed for MAGRs. In particular, the 2nd sextant showed the greatest mRC and CRC in both CAF and CAF + CTG groups compared to 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 to 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 to 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 lower jaw compared to the upper jaw [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 & Ciancio observed a reduced revascularization when verticals incisions were performed [45]. The eCAF was introduced for the treatment of MAGRs to avoid the vertical incisions which may the 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 keratinized tissue width 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 & 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 flap [43] this could also lead to reduced post-operative 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 establish in the literature, thus decreasing the necessity for a priori calibration among the surgeons [8, 18]. Furthermore, we utilized a statistical methodology that controlled (took into account) 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 individual patient data 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 2 of the included trials was 6 months versus 1-year which was the final follow-up of the rest of the included studies.

Conclusion

Within the limitations of the present study, several conclusions can be drawn: i) 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 to the other sextants; ii) maxillary MAGRs displayed a greater mRC and CRC post-treatment than mandibular MAGRs; iii) 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; iv) no differences were observed between vertical releasing CAF and envelop CAF, whether with or without a CTG; v) teeth in the distal part of the flap are related to significantly lower outcomes than teeth in the mesial and central part.

Footnotes

Rstudio Version 1.1.383, RStudio, Inc., Massachusetts, USA

Acknowledgements

The authors certify that there is no conflict of interest concerning the contents of the study. This paper was partially supported by the University of Michigan Periodontal Graduate Student Research Fund.

Conflict of interest and source of funding

The authors do not have any financial interests, either directly or indirectly, in the products or information listed in the paper. This paper was partially supported by the University of Michigan Periodontal Graduate Student Research Fund.

References

1. Lawrence HP, Hunt RJ, Beck JD. Three-year root caries incidence and risk modeling in older adults in North Carolina. J Public Health Dent 1995;55:69-78.

2. Susin C, Haas AN, Oppermann RV, Haugejorden O, Albandar JM. Gingival recession: epidemiology and risk indicators in a representative urban Brazilian population. J Periodontol 2004;75:1377-1386.

3. Cortellini P, Bissada NF. Mucogingival conditions in the natural dentition: Narrative review, case definitions, and diagnostic considerations. J Periodontol 2018;89 Suppl 1:S204-S213.

4. Zucchelli G, Mounssif I. Periodontal plastic surgery. Periodontol 2000 2015;68:333-368.

5. Albandar JM, Kingman A. Gingival recession, gingival bleeding, and dental calculus in adults 30 years of age and older in the United States, 1988-1994. J Periodontol 1999;70:30-43.

6. Gorman WJ. Prevalence and etiology of gingival recession. J Periodontol 1967;38:316-322.

7. Murray JJ. Gingival recession in tooth types in high fluoride and low fluoride areas. J Periodontal Res 1973;8:243-251.

8. Zucchelli G, De Sanctis M. Treatment of multiple recession-type defects in patients with esthetic demands. J Periodontol 2000;71:1506-1514.

9. Tonetti MS, Cortellini P, Pellegrini G, et al. Xenogenic collagen matrix or autologous connective tissue graft as adjunct to coronally advanced flaps for coverage of multiple adjacent gingival recession: Randomized trial assessing non-inferiority in root coverage and superiority in oral health-related quality of life. J Clin Periodontol 2018;45:78-88.

10. Cairo F, Pagliaro U, Nieri M. Treatment of gingival recession with coronally advanced flap procedures: a systematic review. J Clin Periodontol 2008;35:136-162.

11. Cairo F, Nieri M, Pagliaro U. Efficacy of periodontal plastic surgery procedures in the treatment of localized facial gingival recessions. A systematic review. J Clin Periodontol 2014;41 Suppl 15:S44-62.

12. Chambrone L, Sukekava F, Araujo MG, Pustiglioni FE, Chambrone LA, Lima LA. Root-coverage procedures for the treatment of localized recession-type defects: a Cochrane systematic review. J Periodontol 2010;81:452-478.

13. Chambrone L, Lima LA, Pustiglioni FE, Chambrone LA. Systematic review of periodontal plastic surgery in the treatment of multiple recession-type defects. J Can Dent Assoc 2009;75:203a-203f.

14. Graziani F, Gennai S, Roldan S, et al. Efficacy of periodontal plastic procedures in the treatment of multiple gingival recessions. J Clin Periodontol 2014;41 Suppl 15:S63-76.

15. Cairo F. Periodontal plastic surgery of gingival recessions at single and multiple teeth. Periodontol 2000 2017;75:296-316.

16. Bernimoulin JP, Luscher B, Muhlemann HR. Coronally repositioned periodontal flap. Clinical evaluation after one year. J Clin Periodontol 1975;2:1-13.

17. de Sanctis M, Clementini M. Flap approaches in plastic periodontal and implant surgery: critical elements in design and execution. J Clin Periodontol 2014;41 Suppl 15:S108-122.

18. Zucchelli G, Mele M, Mazzotti C, Marzadori M, Montebugnoli L, De Sanctis M. Coronally advanced flap with and without vertical releasing incisions for the treatment of multiple gingival recessions: a comparative controlled randomized clinical trial. J Periodontol 2009;80:1083-1094.

19. Tavelli L, Barootchi S, Nguyen TV, Tattan M, Ravida A, Wang HL. Efficacy of tunnel technique in the treatment of localized and multiple gingival recessions: A systematic review and a meta-analysis. J Periodontol 2018;89(9):1075-1090.

20. Skurska A, Dolinska E, Sulewska M, et al. The assessment of the influence of vertical incisions on the aesthetic outcome of the Miller class I and II recession treatment: a split-mouth study. J Clin Periodontol 2015;42:756-763.

21. Barrella GE, Kolbe MF, Ribeiro FV, et al. Coronally advanced flap with two different techniques for the treatment of multiple gingival recessions: A pilot prospective comparative case series. Quintessence Int 2016;47:39-50.

22. Cairo F, Cortellini P, Pilloni A, et al. Clinical efficacy of coronally advanced flap with or without connective tissue graft for the treatment of multiple adjacent gingival recessions in the aesthetic area: a randomized controlled clinical trial. J Clin Periodontol 2016;43:849-856.

23. Zucchelli G, Mounssif I, Mazzotti C, et al. Coronally advanced flap with and without connective tissue graft for the treatment of multiple gingival recessions: a comparative short- and long-term controlled randomized clinical trial. J Clin Periodontol 2014;41:396-403.

24. Thombre V, Koudale SB, Bhongade ML. Comparative evaluation of the effectiveness of coronally positioned flap with or without acellular dermal matrix allograft in the treatment of multiple marginal gingival recession defects. Int J Periodontics Restorative Dent 2013;33:e88-94.

25. Huang LH, Neiva RE, Wang HL. Factors affecting the outcomes of coronally advanced flap root coverage procedure. J Periodontol 2005;76:1729-1734.

26. Aroca S, Barbieri A, Clementini M, Renouard F, de Sanctis M. Treatment of class III multiple gingival recessions: Prognostic factors for achieving a complete root coverage. J Clin Periodontol 2018;45:861-868.

27. Zucchelli G, Tavelli L, Ravida A, Stefanini M, Suarez-Lopez Del Amo F, Wang HL. Influence of tooth location on coronally advanced flap procedures for root coverage. J Periodontol 2018;89(12):1428-1441.

28. Aroca S, Keglevich T, Barbieri B, Gera I, Etienne D. Clinical evaluation of a modified coronally advanced flap alone or in combination with a platelet-rich fibrin membrane for the treatment of adjacent multiple gingival recessions: a 6-month study. J Periodontol 2009;80:244-252.

29. de Lima V, Bierrenbach AL, Alencar GP, Andrade AL, Azevedo LCP. Increased risk of death and readmission after hospital discharge of critically ill patients in a developing country: a retrospective multicenter cohort study. Intensive Care Med 2018;44:1090-1096.

30. Hong JA, Kim MS, Cho MS, et al. Clinical features of idiopathic restrictive cardiomyopathy: A retrospective multicenter cohort study over 2 decades. Medicine (Baltimore) 2017;96:e7886.

31. Eade T, Choudhury A, Pollack A, et al. Acute Epithelial Toxicity Is Prognostic for Improved Prostate Cancer Response to Radiation Therapy: A Retrospective, Multicenter, Cohort Study. Int J Radiat Oncol Biol Phys 2018;101:957-963.

32. Stefanini M, Zucchelli G, Marzadori M, de Sanctis M. Coronally Advanced Flap with Site-Specific Application of Connective Tissue Graft for the Treatment of Multiple Adjacent Gingival Recessions: A 3-Year Follow-Up Case Series. Int J Periodontics Restorative Dent 2018;38:25-33.

33. Garces-McIntyre T, Carbonell JM, Vallcorba L, Santos A, Valles C, Nart J. Coronal advanced flap in combination with a connective tissue graft. Is the thickness of the flap a predictor for root coverage? A prospective clinical study. J Clin Periodontol 2017;44:933-940.

34. Byun HY, Oh TJ, Abuhussein HM, Yamashita J, Soehren SE, Wang HL. Significance of the epithelial collar on the subepithelial connective tissue graft. J Periodontol 2009;80:924-932.

35. Bates D, Mächler M, Bolker B, Walker S. Fitting Linear Mixed-Effects Models Using lme4. J Stat Softw 2015;67:48.

36. Hofmanner P, Alessandri R, Laugisch O, et al. Predictability of surgical techniques used for coverage of multiple adjacent gingival recessions--A systematic review. Quintessence Int 2012;43:545-554.

37. Tavelli L, Barootchi S, Greenwell H, Wang HL. Is a soft tissue graft harvested from the maxillary tuberosity the approach of choice in an isolated site? J Periodontol 2019. doi:10.1002/JPER.18-0615

38. Rebele SF, Zuhr O, Schneider D, Jung RE, Hurzeler MB. Tunnel technique with connective tissue graft versus coronally advanced flap with enamel matrix derivative for root coverage: a RCT using 3D digital measuring methods. Part II. Volumetric studies on healing dynamics and gingival dimensions. J Clin Periodontol 2014;41:593-603.

39. Pini-Prato GP, Cairo F, Nieri M, Franceschi D, Rotundo R, Cortellini P. Coronally advanced flap versus connective tissue graft in the treatment of multiple gingival recessions: a split-mouth study with a 5-year follow-up. J Clin Periodontol 2010;37:644-650.

40. Rasperini G, Acunzo R, Pellegrini G, et al. Predictor factors for long-term outcomes stability of coronally advanced flap with or without connective tissue graft in the treatment of single maxillary gingival recessions: 9 years results of a randomized controlled clinical trial. J Clin Periodontol 2018;45:1107-1117.

41. McGuire MK, Scheyer ET. Xenogeneic collagen matrix with coronally advanced flap compared to connective tissue with coronally advanced flap for the treatment of dehiscence-type recession defects. J Periodontol 2010;81:1108-1117.

42. Chaparro A, De la Fuente M, Albers D, et al. Root Coverage of Multiple Miller Class I and II Recession Defects Using Acellular Dermal Matrix and Tunneling Technique in Maxilla and Mandible: A 1-Year Report. Int J Periodontics Restorative Dent 2015;35:639-645.

43. Burkhardt R, Lang NP. Fundamental principles in periodontal plastic surgery and mucosal augmentation--a narrative review. J Clin Periodontol 2014;41 Suppl 15:S98-107.

44. Park JC, Kim CS, Choi SH, Cho KS, Chai JK, Jung UW. Flap extension attained by vertical and periosteal-releasing incisions: a prospective cohort study. Clin Oral Implants Res 2012;23:993-998.

45. Mormann W, Ciancio SG. Blood supply of human gingiva following periodontal surgery. A fluorescein angiographic study. J Periodontol 1977;48:681-692.

46. Wang HL, Boyapati L. "PASS" principles for predictable bone regeneration. Implant Dent 2006;15:8-17.

47. Larato DC. Alveolar plate fenestrations and dehiscences of the human skull. Oral Surg Oral Med Oral Pathol 1970;29:816-819.

48. Sanz M, Simion M, Working Group 3 of the European Workshop on P. Surgical techniques on periodontal plastic surgery and soft tissue regeneration: consensus report of Group 3 of the 10th European Workshop on Periodontology. J Clin Periodontol 2014;41 Suppl 15:S92-97.

49. Cortellini P, Tonetti M, Baldi C, et al. Does placement of a connective tissue graft improve the outcomes of coronally advanced flap for coverage of single gingival recessions in upper anterior teeth? A multi-centre, randomized, double-blind, clinical trial. J Clin Periodontol 2009;36:68-79.

50. Chambrone L, Prato GPP. Clinical insights about the evolution of root coverage procedures: The flap, the graft, and the surgery. J Periodontol 2019;90(1):9-15

51. Baldi C, Pini-Prato G, Pagliaro U, et al. Coronally advanced flap procedure for root coverage. Is flap thickness a relevant predictor to achieve root coverage? A 19-case series. J Periodontol 1999;70:1077-1084.

52. Stefanini M, Jepsen K, de Sanctis M, et al. Patient-reported outcomes and aesthetic evaluation of root coverage procedures: a 12-month follow-up of a randomized controlled clinical trial. J Clin Periodontol 2016;43:1132-1141.

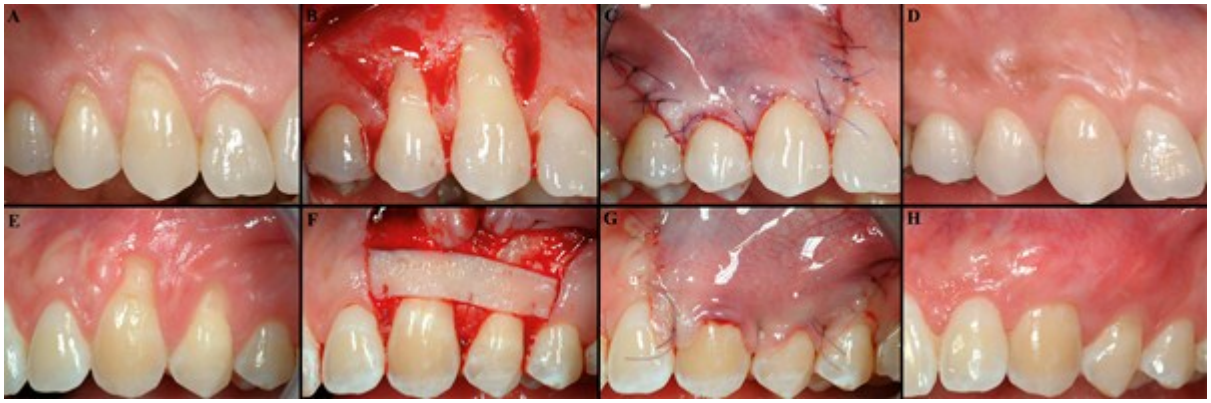
53. Azaripour A, Kissinger M, Farina VS, et al. Root coverage with connective tissue graft associated with coronally advanced flap or tunnel technique: a randomized, double-blind, mono-centre clinical trial. J Clin Periodontol 2016;43:1142-1150.

Figure Legend

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) Post-operative pictures showing the closure by primary intention D) 1-year outcomes; A) Baseline; B) A connective tissue graft was positioned and sutured over the root of the canine and the premolar; C) Post-operative pictures showing the closure by primary intention D) 1-year outcomes



Tables

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

	CAF			CAF+CTG		
Sextant	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*	62	95.5 ± 9.4	79.3
4	15	74.4 ± 26.8*	49.7	36	90.9 ± 13.7	64.3
5	5	58.3 ± 9.6*	25*	35	88.6 ± 21.1	61.3
6	13	61.2 ± 18.3*	38.5*	30	92.7 ± 11.8	59.1

Sextants description: 1st: right maxilla; 2nd: anterior maxilla; 3rd: left maxilla; 4th: left mandible; 5th: lower anterior and 6th: right mandible.

*signifies 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, 0.18]	0.43
	Smoking	2.68 [-11.56, 16.61]	0.71
	Vertical releasing incisions	-2.28 [-9.64, 5.09]	0.54
	Arch (Maxilla)	4.86 [2.4, 7.3]	<0.001
	Anterior vs Posterior (Posterior)	-3.76 [-6.02, -1.5]	<0.001
CAF + CTG	Age	-0.19 [-0.56, 0.18]	0.56
	Smoking	2.06 [-2.42, 6.54]	0.58
	Vertical releasing incisions	-1.04 [-3.02, 0.94]	0.35
	Arch (Maxilla)	3.2 [-0.54, 6.94]	<0.001
	Anterior vs Posterior (Posterior)	-1.52 [-4.7, 1.65]	0.34