J Clin Periodontol 2011; 38: 661–666 doi: 10.1111/j.1600-051X.2011.01732.x

Journal of Clinical Periodontology

The interproximal clinical attachment level to classify gingival recessions and predict root coverage outcomes: an explorative and reliability study

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Cairo F, Nieri M, Cincinelli S, Mervelt J, Pagliaro U. The interproximal clinical attachment level to classify gingival recessions and predict root coverage outcomes: an explorative and reliability study. J Clin Periodontol 2011; 38: 661–666. doi: 10.1111/j.1600-051X.2011.01732.x.

Abstract

Background: The aims of this study were (i) to test the reliability of a new classification system of gingival recessions using the level of interproximal clinical attachment as an identification criterion and (ii) to explore the predictive value of the resulting classification system on the final root coverage outcomes.

Material and methods: Patients showing at least one buccal gingival recession were recruited by one operator. Three recession types (RT) were identified. While class RT1 included gingival recession with no loss of interproximal attachment, class RT2 recession was associated with interproximal attachment loss less than or equal to the buccal site and class RT3 showed higher interproximal attachment loss than the buccal site. The classification was tested by two examiners blinded to the data collected by the other examiner. Intra-rater and inter-rater agreement was assessed. Furthermore, the 6-month root coverage outcomes of consecutively treated gingival recessions were retrospectively evaluated in order to explore the predictive value of the proposed classification on the final recession reduction (Rec Red).

Results: The new classification system of gingival recessions was tested in a total of 116 gingival recessions (mean 3.2 ± 1.2 mm) in 25 patients. The intra-class correlation coefficient (ICC) for inter-rater agreement was 0.86, showing an almost perfect agreement between the examiners. The RT classification was predictive of the final Rec Red ($p < 0.0001$) at the 6-month follow-up in 109 treated gingival recessions.

Conclusions: The evaluation of interproximal clinical attachment level may be used to classify gingival recession defects and to predict the final root coverage outcomes.

Key words: aesthetics; classification; clinical attachment level; diagnosis; gingival recession; periodontal disease; root coverage

Accepted for publication 20 March 2010

Marginal tissue recession is defined as the displacement of the soft tissue margin apical to the cemento-enamel junction (CEJ) (American Academy of Periodontology 1996) and it is a frequent clinical feature in the general population (Baelum et al. 1986, Yoneyama et al. 1988, Löe et al. 1992, Serino et al. 1994). Localized loss of attachment with gingival recession is frequently located at buccal tooth surfaces in patients with high standards of oral hygiene (Löe et al. 1992, Serino et al. 1994) and may be associated with mechanical factors such as traumatic tooth-brushing (Sangnes & Gjermo 1976) and orthodontic movement (Joss-Vassalli et al. 2010), even if no definitive evidence is currently available (Rajapakse et al. 2007).

Some classifications of gingival recession are reported in the periodontal

Conflict of interest and source of funding statement

The authors certify that there is no conflict of interest concerning the contents of the study. This study has been self-supported by the authors.

literature. In a classical article, soft tissue defects at mandibular incisors were divided into four classes: ''narrow'', ''wide'', ''shallow'' and ''deep'' (Sullivan & Atkins 1968). Better root coverage outcomes following a gingival graft procedure for narrow-shallow defects were reported (Sullivan & Atkins 1968). Mlinek et al (1973) identified ''shallow-narrow'' defects as recession <3 mm, while ''deep-wide'' defects were recessions >3 mm. Miller (1985) proposed four classes of marginal tissue recessions based on both the level of gingival margin with respect to the muco-gingival junction (MGJ) and the underlying alveolar bone. In class I, the recession did not extend to the MGJ, while in class II the gingival margin reached MGJ, both showing no loss of interproximal bone. In the class III recession defect, the gingival margin was located to or beyond the MGJ with interproximal bone loss and/or tooth malpositioning. Finally, class IV showed serious interproximal bone loss and/or severe tooth malpositioning. More recently, a compound index of recession was also proposed (Smith 1997) to assess both vertical and horizontal extent of the defect. The degree of horizontal component was expressed as a value ranging from 0 to 5 depending on the severity of CEJ exposure, while the vertical extent of recession was measured in millimetres using a periodontal probe on a 0–9 range (Smith 1997).

In the last two decades, Miller' classification has become very popular and is widely used. Recently, some criticisms to this classification were reported such as the difficult differential diagnosis between Miller class I and II, the unclear procedures to ascertain the amount of soft/hard tissue loss in the interdental area to differentiate class III and IV and the unclear influence of tooth malpositioning (Pini-Prato 2011). Furthermore, the possible need for a new classification system taking into account the progress made in the diagnosis and in the treatment of gingival recessions has been suggested recently (Mahajan 2010) in order to improve the simplicity of the diagnosis and the standardization of the clinical case. Finally, reliability and validity are central to determining the utility of any clinical parameters (Karras 1997) but information on the reliability of the published systems as the Miller's classification is currently not available and no general consensus on the use of a specific system exists.

Clinical variables involved in gingival recession might also be evaluated for anticipating a possible prognosis of root coverage outcomes. Miller (1985) hypothesized the feasibility of complete root coverage (CRC) using the free gingival graft (FGG) procedure for class I and II, only a partial coverage for class III and no root coverage for class IV. More recently, other possible prognostic factors such as the amount of baseline recession (Clauser et al. 2003), the dimension of interdental papilla (Saletta et al. 2001) and the tooth type (Müller et al. 1998) were suggested as being likely to influence the final outcomes. On the other hand, the possible loss of interproximal attachment may also be able to predict the recession reduction (Rec Red).

The aims of this study were:

1. To test the reliability of a new classification system of gingival recessions using the level of interproximal clinical attachment as an identification criterion.
2. To explore the predictive value of the resulting classification system on the final root coverage outcomes.

Material and Methods

Part 1: Reliability study of a new classification of gingival recessions using the interproximal CAL

Patients showing at least one buccal gingival recession were consecutively recruited by the same periodontist (F. C.) in order to test the reliability of a new classification of gingival recession defects. All patients were recruited in the same private practice setting and signed a written informed consent in accordance with the Helsinki Declaration of 1975 as revised in 2000. Entry criteria were:

- The presence of a buccal recession defect at one or more teeth, irrespective of the amount of clinical attachment loss at the interproximal sites.
- Completion of causal-related therapy when necessary.
- Full-mouth plaque score (FMPS) and Full-mouth bleeding score (FMBS) $<15\%$ (four sites/tooth).
- Detectable CEJ at the tooth with a recession.

Exclusion criteria were:

- Tooth with a prosthetic crown or restoration involving CEJ.
- Presence of dental/root abrasion at the CEJ level.

The following periodontal variables were recorded in a preliminary evaluation:

- Recession depth (REC) at both buccal and interproximal sites.
- Probing depth (PD) at both buccal and interproximal sites.
- Clinical attachment level (CAL) at both buccal and interproximal sites was then calculated.

Taking into account the desirable characteristics of a classification system (usefulness, exhaustiveness, disjointness and simplicity) suggested by Murphy (1997), the following classification of gingival recession was then identified based on the assessment of CAL at both buccal and interproximal sites.

- Recession Type 1 (RT1): Gingival recession with no loss of interproximal attachment. Interproximal CEJ was clinically not detectable at both mesial and distal aspects of the tooth (Fig. 1a–c).
- Recession Type 2 (RT2): Gingival recession associated with loss of interproximal attachment. The amount of interproximal attachment loss (measured from the interproximal CEJ to the depth of the interproximal pocket) was less than or equal to the buccal attachment loss (measured from the buccal CEJ to the depth of the buccal pocket) (Fig. 2a–c).
- Recession Type 3 (RT3): Gingival recession associated with loss of interproximal attachment. The amount of interproximal attachment loss (measured from the interproximal CEJ to the depth of the pocket) was higher than the buccal attachment loss (measured from the buccal CEJ to the depth of the buccal pocket) (Fig. 3a–c).

When both mesial and distal sites of the experimental tooth showed a CEJ with associated attachment loss, the interproximal site with the highest loss of attachment was considered for the identification of the type of recession.

Validation session

Two periodontal examiners (J. M.-examiner n.1 and S. C.-examiner n.2)

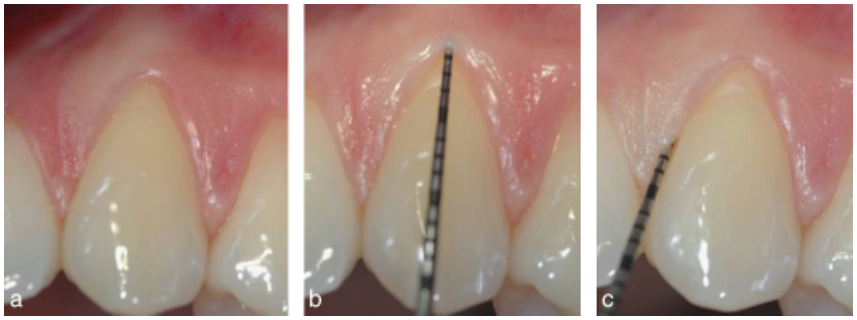

Fig. 1. (a) A buccal gingival recession at the upper left canine, (b) the level of buccal clinical attachment was 3 mm, (c) the interproximal cemento-enamel junction is not detectable: the final diagnosis is recession type 1.

Fig. 2. (a) A buccal gingival recession at the upper left canine, (b) the level of buccal clinical attachment was 4 mm, (c) the level of interproximal clinical attachment was 3 mm: the final diagnosis is recession type 2.

Fig. 3. (a) A buccal gingival recession at the upper left lateral incisor, (b) the level of buccal clinical attachment was 6 mm, (c) the level of interproximal clinical attachment was 8 mm: the final diagnosis is recession type 3.

were recruited for the study. Both examiners were informed about and trained on the use of the proposed classification system and were blinded with respect to the evaluation of the first author (F. C.). All needed clarifications were provided before the study. Only one private office was involved in the study.

The examiners evaluated each selected gingival recession twice, independently and blindly. REC, PD and CAL were recorded for each defect. The examiners rated the recessions using the above-mentioned classification system. There was no time restriction during the procedure.

Sample size calculation

The sample size to test the reliability of the new classification of gingival recessions was calculated using a minimal acceptance level of an intra-class correlation coefficient (ICC) of 0.80 with an alternative hypothesis of 0.90, 2 operators, $\alpha = 0.05$ and $\beta = 0.01$ (Walter et al. 1998). With these parameters, the required number of recessions was 114.

Part 2: Retrospective analysis to explore the predictive value of the resulting classification system on root coverage outcomes

Subsequently, the primary author (F. C.) selected periodontal chartings of patients treated with different mucogingival procedures, including gingival augmentation. All patients were consecutively treated by the same operator (F. C.) in a private practice setting from January 2006 to December 2008. Gingival recessions with or without interproximal loss of clinical attachment at baseline were included in this retrospective analysis. In order to explore the predictive value of interproximal CAL on the 6-month root coverage outcomes, the following periodontal variables were then collected:

- the baseline depth of gingival recession (REC 0) at the buccal site,
- the baseline clinical attachment level (CAL B 0) at the buccal site,
- the baseline clinical attachment level (CAL int) at interproximal sites,
- the final depth of gingival recession (REC 1) at the buccal site,
- the resulting Rec Red following therapy,
- the type of surgical procedure.

The type of gingival recession (RT1, RT2 or RT3) was then assessed retrospectively.

Statistical Analysis

Descriptive statistics with mean ± standard deviation [minimum; maximum] were performed.

The two-way random ICC and 95% confidence interval (CI) were used to assess the intra-rater and inter-rater agreement among the two periodontal examiners for the RT and REC. In addition, inter-rater agreement (ICC and 95% CI) were also assessed among the two periodontal examiners and the first author (F. C.).

These statistical analyses were performed using R software (version 2.9.2, The R Foundation for Statistical Computing, Package ''irr'').

A six-level nomenclature was used to assess the level of agreement (Landis & Koch 1977):

- poor agreement: < 0.00,
- slight agreement: 0.00–0.20,
- fair agreement: 0.21–0.40,
- moderate agreement: 0.41–0.60,
- substantial agreement: 0.61–0.80,
- almost perfect agreement: 0.81–1.00.

In order to explore the predictive value of RT1 and RT2 class on Rec Red outcome, a mixed model (REML) was used with the patient as a random effect and REC 0 and RT as explicative variables. RT3 recessions were not included in this analysis as these defects

Table 1. Reliability study of the new classification of gingival recession: distribution of recession type (RT) at different teeth

Class	Upper incisors	Upper cuspids	Upper pre-molars	Upper molars	Lower incisors	Lower cuspids	Lower pre-molars	Lower molars	Total
RT1	1	14	3	-	6	4	3	1	32
RT2	14	5	12	-	15	2	2	-	50
RT3	7	6	3	2	9	3	4	-	34
	22	25	18	**2**	30	9	9	1	116

were treated only for gingival augmentation and not for root coverage finality.

Results

A total of 25 patients (mean age 43.9 ± 11.7 years [23; 66]) were enrolled in order to test the reliability of a new classification of gingival recession. Sixteen patients were females. A total of 116 gingival recessions were evaluated. The mean buccal recession assessed by the primary author before the validation session was 3.2 ± 1.2 mm [1; 6]. Sixty-seven were located in the maxillary arch and 49 recessions were scored in the lower jaw. Twenty-two defects were found at the upper incisors, 30 at lower incisors, 25 at upper cuspids, nine at lower cuspids, 18 at upper pre-molars, nine at lower pre-molars, two at the upper molars and one at a lower molar. Based on the preliminary assessment of the first author (F. C.), a total of 32 defects (28%) were considered as class RT1, 50 as class RT2 (43%) and the 34 as class RT3 (29%). The details of the descriptive statistics are reported in Table 1.

ICC and 95% CI between the two examiners (inter-rater agreement) were calculated for RT and REC. It was 0.86 (0.80;0.90) for the RT class and 0.88 (0.83;0.91) for REC, showing an almost perfect agreement for both the variables. The ICC for intra-rater agreement was 0.93 for the variable RT and ranged from 0.87 to 0.93 for the variable REC (Table 2). ICC and 95% CI for RT and REC were also assessed among the two periodontal examiners and the primary author (F. C.). On comparing examiner 1 with the primary author, the ICC was 0.90 (0.86;0.93) for RT and 0.86 (0.80;0.90) for REC. On comparing examiner 2 with the primary author, the ICC was 0.88 (0.83;0.91) for RT and 0.89 (0.85;0.93) for REC.

A different group of 66 patients (36 females and 30 males) treated with different mucogingival procedures was enrolled in the study in order to explore the predictive value of RT class on the final root coverage outcomes. The mean age was 37.6 ± 11.4 years [21; 62]; 19 patients were smokers. The treatment outcomes of 133 gingival recessions were then evaluated: 5% were at central upper incisors, 10% at lateral upper incisors, 30% at upper cuspids, 15% at upper pre-molars, 3% at upper molars, 19% at lower incisors, 10% at lower cuspids, 7% at lower pre-molars and 1% at lower molar. The mean baseline buccal recession defect was 3.0 ± 1.1 mm [1; 8]; the mean buccal loss of attachment was 4.1 ± 1.3 mm [2; 9]; and the mean loss of interproximal attachment was 1.6 ± 2.5 mm [0; 8]. A total of 35 recessions were treated using the coronally advanced flap for multiple recessions (CAF multi), 19 recessions with coronally advanced flap for single recession (CAF), 28 recessions with CAF plus connective tissue graft (CAF+CTG), 36 recessions with the FGG, eight recessions with double papilla flap with a connective tissue graft (DPF+CTG), three recessions with CAF plus enamel matrix derivative (CAF+EMD), two recessions with the laterally positioned flap and two recessions with FGG+CAF.

Table 2. Reliability study of the new classification of gingival recession: intra-rater agreement for examiner n.1 (J. M.) and examiner n.2 (S. C.) for recession type (RT) and recession depth (REC)

Variable	Examiner n.1: ICC (95% CI)	Examiner n.2: ICC (95% CI)
RT class	0.93 (0.90;0.95)	0.93 (0.90;0.95)
REC	0.93 (0.89;0.95)	0.87 (0.82;0.91)

ICC, intra-class correlation coefficient; 95% CI, 95% confidence interval.

Table 3. Descriptive statistics of defects analysed in the explorative analysis for the predictive value of the proposed classification on the final recession reduction

Variable	RT1 ($n = 76$)	RT2 ($n = 33$)	RT3 ($n = 24$)
REC 0 (mm)	2.8 ± 1.0	3.2 ± 1.4	3.5 ± 0.5
CAL B 0 (mm)	3.9 ± 1.0	4.3 ± 1.5	4.6 ± 0.7
CAL int (mm)	0 ± 0	1.6 ± 0.6	6.6 ± 0.8
Rec Red (mm)	2.5 ± 0.9	2.2 ± 0.8	0.4 ± 0.9
REC 1 (mm)	0.3 ± 0.5	1.1 ± 0.9	3.3 ± 0.6
Sites with CRC	56 (74%)	8 (24%)	0 (0%)

The defects were retrospectively categorized according to gingival recession types.
RT1, Recession Type 1; RT2, Recession Type 2; RT3, Recession Type 3; REC 0, buccal recession at the baseline; CAL B 0, buccal clinical attachment level; CAL int, interproximal clinical attachment level at baseline; Rec Red, recession reduction; REC 1, buccal recession at the 6-month follow-up; Sites with CRC, number of defects with complete root coverage at the 6-month follow-up.

Table 4. Mixed model (REML) using patient as a random effect to explore the predictive value of REC 0, RT1 and RT2 on the recession reduction outcome. $N = 109$; $R^2 = 0.83$

	Estimate	Standard error	*p*-value
Intercept	0.40	0.17	
REC 0	0.65	0.05	<0.0001
Class [RT1]	0.29	0.07	<0.0001

REC 0, baseline depth of gingival recession at both buccal site; Class, recession type.

In Table 3, the details of the descriptive statistics of treated gingival recessions included in the explorative study for the predictive value of RT class are reported. The mixed model (Table 4) was limited to 109 out of the 133 selected defects, corresponding to classes RT 1 and RT2 recessions only. Data for the residual 24 RT3 recessions treated with gingival augmentation pro-

cedure were excluded from the analysis as the treatment had no root coverage finality. The results of the analysis showed that RT class is a strong predictor ($p < 0.0001$) of the final Rec Red (Table 4). When considering a similar baseline REC 0 for RT1 and RT2 classes, RT1 showed a higher mean Rec Red (0.57 mm) compared with RT2 (95% CI: from 0.31 to 0.84 mm).

Discussion

The treatment of gingival recession is a common question in patients with a high standard of oral hygiene. Different surgical procedures are associated with the CRC (Cairo et al. 2008) and the final improvement of aesthetics (Cairo et al. 2009, Kerner et al. 2009, Cairo et al. 2010). The classification of the type of gingival recession is a very important issue in clinical trials dealing with root coverage procedures. In the last two decades, Miller's classification has become a very popular approach in identifying soft tissue recessions (Miller 1985). Recently, the use of Miller's classification was reviewed and the difficult inclusion for some recessions in a specific class was outlined (Mahajan 2010, Pini-Prato 2011). The development of a new classification system of gingival recession on the basis of the characteristics of suitable taxonomy and validated by reliability study for its use in clinical practice was then advocated (Pini-Prato 2011).

The first aim of this study was to test the reliability of a new classification system for gingival recessions using the level of interproximal CAL as an identification criterion. This approach is based on the observation that the CAL is used extensively to evaluate periodontal conditions (Papapanou & Lindhe 2008). The interproximal CAL may also be considered as a reliable tool to indirectly assess the presence of bone loss (Papapanou & Wennström 1989). In this classification, gingival recessions without loss of interproximal attachment were considered as RT1 defects, representing defects most likely associated with traumatic toothbrushing only in healthy periodontal tissue. Gingival recessions associated with the presence of clinical attachment loss were divided into classes RT2 and RT3, thus clustering defects associated with periodontal disease. While RT2 defects showed an amount of interproximal attachment less than or equal to the buccal site (i.e. a gingival recession associated with horizontal bone lone loss), RT3 recessions showed higher interproximal attachment loss than the buccal site (i.e. a gingival recession associated with an interproximal infrabony defect). This differential diagnosis may help clinicians in selecting the proper treatment.

The reliability of this system is confirmed by the intra-rater agreement (ICC = 0.86), with an almost perfect agreement between the two examiners. Similar outcomes were obtained on assessing intra-rater reliability and comparing the two examiners with the primary author. A possible explanation for these findings may be related to the fact that only defects with a CEJ showing no tooth abrasion in the cervical area were included, leading to a simple CAL assessment. Furthermore, only patients with minimal gingival inflammation (FMPS and FMBS $< 15\%$) were enrolled in this study, thus reducing the possible apical displacement of the probe tip during the measurements (Armitage et al. 1977). This condition may have improved the reliability of the measurements. It must also be taken into account that no assessment of keratinized tissue (KT) surrounding the gingival recession was performed in this classification. Although the baseline KT amount might be useful in the selection of the surgical procedure, the influence of KT on root coverage outcomes is still a controversial topic (Cairo et al. 2008). On the other hand, if the final target of the procedure is the CRC along with an increase of KT, the combination between CAF+CTG was associated with better clinical outcomes (Cairo et al. 2008).

The prediction of the amount of Rec Red following root coverage is another important issue in current practice. Recently, a method of pre-determination of the final position of the gingival margin using the height of the interdental papilla was suggested (Zucchelli et al. 2010). This procedure was able to predict in 71% of treated cases the position of the gingival margin 3 months after surgery (Zucchelli et al. 2010). The second aim of our study was to explore the predictive value of RT class on the final root coverage outcomes. The results of the analysis showed that this variable is a strong predictor ($p < 0.0001$) of the final Rec Red after different surgical procedures. It should be hypothesized that the level of interproximal CAL is the coronal limit of the achievable amount of root coverage at the buccal site after surgery. This may be associated with stability and blood supply provided by interproximal soft tissue to the buccal flap/graft during the healing process. When considering a similar baseline REC 0 for RT1 and RT2 classes, RT1 showed a higher mean Rec Red (0.57 mm) compared with the RT2 class: this finding supports the importance of baseline interproximal CAL for the prognosis of gingival recession treatment. Interestingly, 8 out of 33 RT2 defects (24%) reported CRC after different root coverage procedures. Although it is suggested that only a partial root coverage can be anticipated for gingival recession with interdental bone loss (Miller 1985), this finding supports the initial observations from a randomized study reporting the feasibility of CRC for multiple recessions with interproximal bone loss and treated with the tunnel technique plus CTG (Aroca et al. 2010). However, further well-designed trials are needed to explore the predictability of CRC in relation to specific surgical procedures for the treatment of single RT2 recession defects. On the other hand, RT3 recessions were not included in this explorative analysis as these defects were treated with FGG only for gingival augmentation and not for root coverage finality. However, a slight coronal improvement of the gingival margin was detected at the 6-month follow-up (mean Rec Red 0.4 ± 0.9), probably associated with a creeping attachment following FGG (Matter 1980). Based on this observation, it might be hypothesized that interdental soft/hard tissue reconstruction with a gain in clinical attachment seems to be mandatory before considering a predictable root coverage procedure at the buccal site in RT3 recessions.

The limits of this explorative study may be related to the selection of gingival recessions associated with a completely detectable CEJ for assessing the reliability of the new classification system of gingival recession. On the other hand, a recent study proposing a classification of dental defects in areas with gingival recession reported that CEJ may not be identifiable in some cases (Pini-Prato et al. 2010). In this condition, a different fixed point for CAL assessment, such as the incisal margin, is needed. However, a possible combination of both classifications for asses-

sing soft and hard tissue defects may be recommended. Furthermore, it must be taken into account that the assessment of the predictive value of RT class on the final root coverage outcomes represents a retrospective analysis. Further well-designed prospective randomized studies are recommended to better explore the influence of interproximal CAL along with other potential prognostic factors that may be patient related (e.g. smoking habits), tooth/site related (e.g. the baseline REC, the presence of root abrasion) and technique related (the use CTG, the type of flap design) on the final root coverage outcomes.

In conclusion, this study suggests that the evaluation of interproximal CAL may be used to classify gingival recession defects and to predict the final root coverage outcomes.

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Clinical Relevance

Scientific rationale for the study: No information on the reliability of classifications of gingival recessions is currently available and there is no general consensus on the use of a specific system. In addition, the prediction of the gingival margin position following root coverage is a controversial issue.

Principal findings: Using the level of interproximal clinical attachment as an identification criterion, the proposed classification of gingival recessions showed an ICC = 0.86 (almost perfect agreement) among different examiners. Furthermore, the proposed classification was predictive of the final root coverage outcomes at the 6-month follow-up.

Practical implications: A classification system of gingival recessions based on the interproximal CAL may aid clinicians in a reliable categorization of defects and an effective prediction of treatment outcomes.