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Prediction of root coverage for single recessions in anterior teeth: a 6-month study

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Abstract

Background: The aim of this study was to evaluate the predictive values of baseline inter-dental papilla height (IPH), loss of inter-dental papilla height (LPH), avascular exposed root surface area (AERSA) and inter-dental clinical attachment level (ICAL) measurements on complete root coverage (CRC) of single recession defects treated with coronally advanced flap and connective tissue graft technique (CAF+CTG).

Material & Methods: A total of 122 patients with one isolated gingival recession were enrolled. All recession defects without loss of ICAL (ID-CAL) (RT1) and with an amount of ID-CAL equal or smaller to the buccal attachment loss (RT2), located at upper and lower anterior teeth were treated with CAF+CTG. IPH, LPH, AERSA and ICAL parameters were analysed for possible correlation with CRC after 6 months.

Results: The CRC was 86.7% for RT1, 74.2% for RT2 groups. The ROC analyses revealed acceptable cut-off points for baseline AERSA, IPH and LPH for achieving CRC. The results of logistic regression analyses showed that having baseline AERSA$\geq$19 mm^2 (OR:23.7), IPH lower $\leq$1 mm (OR:97.3) and belonging to RT2 group (OR:15.0) were found to be independent risk factors related with not achieving final CRC.

Conclusion: This study indicates that AERSA and IPH may be used to predict the final CRC outcomes in RT1 and RT2 defects treated with CAF+CTG.

Key words: connective tissue graft; coronally advanced flap; diagnosis; gingival recession; mucogingival surgery

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The coronally advanced flap (CAF) with connective tissue graft (CTG) has been confirmed as the gold standard for treatment of gingival recessions (GR) (Buti et al. 2013, Cairo et al. 2014, Sanz & Simion 2014, Tonetti & Jepsen 2014, Fernandes-Dias et al. 2015). CTG-based procedures provide the best outcomes with superior percentages of mean root coverage (MRC), complete root coverage (CRC) and keratinized tissue (KT) gain (Chambrone & Tatakis 2015). Data in previous reports show CRC range from 18% to 83% after CAF+CTG in Miller Classes I and II defects which are associated with no loss of inter-dental clinical attachment level (ID-CAL) (Recession Type 1-RT1) (Tatakis & Trombelli 2000, Cairo et al. 2011, Pini-Prato 2011, Ozcelik et al. 2015, Zucchelli & Mounssif 2015).

Cairo et al. (2012) stated that the use of CTG under CAF significantly enhances the probability to achieve CRC (%80) in recessions in which ID-CAL is equal or smaller than the buccal attachment loss (Recession Type 2-RT2). The author also emphasized that CRC percentage was very similar to the result (60%) of a multicentre study on the treatment of RT1 recessions (Cortellini et al. 2009). Moreover, CRC was higher than most of the reports on treatment of RT1 or Miller I and II defects (more than 80%) when baseline ID-CAL was between 1 and

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3 mm (Cairo et al. 2012). Therefore, various CRC outcomes of the literature indicate that there is need for additional defect defining criteria for predicting the outcomes of root coverage (RC) in RT 1 and RT2 (ID-CAL ≤3 mm) recession defects.

Prediction of final RC which is important for distinguishing “expected *versus* actual” amount of RC was analysed by several studies (Aichelmann-Reidy et al. 2001, Zucchelli et al. 2006, 2010, Cairo et al. 2011, Ozcelik et al. 2015). The predictive values of inter-dental papilla height (IPH) (Saletta et al. 2001, Aroca et al. 2010, Zucchelli et al. 2010), loss of inter-dental papilla height (LPH) (Aroca et al.2010) and inter-dental clinical attachment level (ICAL) (Cairo et al. 2011, 2012, Pini-Prato et al. 2015) were proven by the clinical studies which reported correlation between these two anatomical characteristics and CRC. Recently, a new predictive classification of GR using the baseline avascular exposed root surface area (AERSA) as an identification criterion has been proposed (Ozcelik et al. 2015). In this study, AERSA resulted as a strong predictor of final RC after laterally positioned flap (LPF) leading to a prognostic model with AERSA explaining 86% of the mean root coverage. In addition Ozcelik et al. (2015) emphasized that, due to anatomic variations, some Miller Class I defects may have larger AERSA than Miller Class II and III defects or there may be smaller Miller Class III defects than Miller Class I and II defects which may significantly influence the treatment results. These results could help to explain the outcome variations among previous studies.

The prognostic anticipation of a certain amount of RC is a complex process including patient-related, tooth/site-related (GRD, root abrasion, ICAL, tooth type, the dimension of inter-dental papilla, AERSA) and technique-related (e.g. quality of the CTG) factors and operator’s skill. It is essential to define the most potent prognostic factors’ combination which can increase the success and predictability rates, to make CAF+CTG the most convenient RC technique for patients and clinicians. Therefore, the aim of this study was to explore the predictive values of baseline IPH, LPH, AERSA and ICAL measurements on the final RC outcomes after CAF+CTG in RT1 and RT2 class GR defects.

Material and Methods

Study design and patient selection

One hundred and twenty-six patients, 66 females and 60 males, aged between 20 and 42 years, with isolated single recessions were included in this prospective study. The patients were referred to the Periodontology Department of Cukurova University between January 2013 and June 2014. The approval of the Local Ethics Committee of Cukurova University Faculty of Dentistry was obtained (CUDHF-2012-8-2). All participants were informed about the study procedures, their associated risks and benefits and they signed an informed consent form in accordance with Helsinki Declaration of 1975 as revised in 2000.

Inclusion criteria were:

- Presence of isolated RT1 and RT2 (Cairo et al. 2011) class GR with an AERSA >9 mm^2 (Ozcelik et al. 2015) on upper and lower anterior teeth,
- Presence of identifiable cemento-enamel junction (CEJ); presence of a step ≤1 mm at the CEJ level and/or the presence of a root abrasion, but with an identifiable CEJ,
- Full-mouth plaque and bleeding score of < 15%,
- No occlusal interferences;

Exclusion CRITERIA were:

- Patients with a history of severe periodontitis,
- Periodontal surgery at the experimental site in the last 1 year,
- Presence of systemic disease or taking medication known to interfere with periodontal health,
- Smokers, pregnant patients.

Sample size

Assuming that the 10% of the defects in RT1 group (Zucchelli et al. 2003) and 20% of the defects in the RT2 group (Cairo et al. 2012) will not have CRC at the end of 6 months, the estimated sample size was found to be 125 defects with 80% power and 95% confidence interval.

Clinical measurements

One blinded trained examiner (M.C.H.) performed all clinical measurements at each selected site using a periodontal probe (1 mm increment) (PCP-UNC15; Hu-Friedy, Chicago, IL, USA). Calibration of the examiner was conducted prior to the study to ensure the intra-examiner reproducibility of the clinical measurements. The examiner evaluated six subjects who were not involved in the study and had teeth with RT1 and RT2 isolated recession defects, on two occasions 24 h apart. The intra-class test was used to determine the intra-examiner reproducibility of all measurements for relative to GR. The examiner reached values of intra-class correlation >0.8.

After initial treatment (at baseline) and 6 months after surgery, the following clinical parameters were recorded to the nearest millimetre:

Probing depth; at buccal site (PD buc), mesial site (PD mes), distal site (PD dis).

Loss of clinical attachment level; as Buccal recession+PD-Buc (CAL-buc), as Mesial recession+PD Mes (CAL mes), as Distal recession+PD Dis (CAL dis).

KT: Keratinized tissue measured from the most apical point of the gingival margin to the MGJ at the middle buccal point.

Height of mesial and distal inter-dental papilla (IPH mes, IPH dis): Measured as the distance from the apex of the papilla to the mid-point of the base of the papilla (Saletta et al. 2001).

The loss of inter-dental papilla height of mesial (LPH mes) and distal site (LPH dis): Measured as the distance between the contact point and the papilla tip (Aroca et al. 2010).

GRD: Recession depth at the central buccal site measured from CEJ to the gingival margin.

GRW: Recession width measured as the distance between the mesial GM and the distal GM of the tooth (on a horizontal line tangenital at the CEJ).

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AERSA was calculated as GRDxGRW.

MRC-unidimensional (MRC-UD), obtained by formula:((GRD-baseline)–(GRD-6thmonth)/GRDbaseline)x100; MRC-multidimensional (MRC-MD), obtained by formula ((AERSA-baseline)–AERSA-6thmonth)/AERSA-baseline)$\times$100.

Complete root coverage, was calculated according to the current international standards (Miller 1985).

Treatment

The cause-related therapy was completed prior to surgery. A coronally directed roll technique was instructed to eliminate traumatic toothbrushing related to the aetiology of the recession. The gingival index (Löe & Silness 1963) and plaque index (Löe 1967) were used to assess gingival health conditions throughout the study.

All patients with isolated GR were treated with CAF+CTG technique by the same experienced periodontist (O.O.). Following local anaesthesia; the exposed root surfaces were gently debrided with curettes from the CEJ to the intracrevicular space and were conditioned with 24% EDTA for 2 min. After EDTA application, the root surface was rinsed with saline for 60 s. The surgery was performed as described by Cairo et al. (2012). Briefly, two oblique, divergent releasing incisions extending beyond the mucogingival junction (MGJ) were performed. An intra-sulcular incision was performed at the buccal aspect of the involved tooth. A full thickness flap until the MGJ was then elevated. Subsequently, a partial-thickness flap was raised beyond the MGJ. The papilla adjacent to the involved tooth was then de-epithelialized.

The CTG was harvested using a single incision approach from the palate (Lorenzana & Allen 2000). The graft was harvested from the area between the second pre-molar and the second molar with a 15c blade (Swan-Morton, England). The palatal wound was sutured after harvesting the CTG (Polypropylene 6-0, Propilen; Dogsan, İstanbul, Turkey). The graft was positioned on the instrumented root surface immediately apical of the CEJ and then stabilized using a sling compressive crossing suture (Polypropylene 7-0, Propilen; Dogsan). The flap was coronally displaced 1–2 mm above the CEJ. A sling suture was placed to stabilize the flap in a coronal position, followed by interrupted sutures on the releasing incisions with an apico-coronal direction (Polypropylene 7-0, Propilen; Dogsan).

Post-surgical protocol

Patients were instructed to abstain from mechanical trauma, chewing, brushing and flossing for 3 weeks around the surgical area. The patients were prescribed 600 mg ibuprofen as needed. The sutures were removed 10 days after surgery. Plaque control in the surgically treated area was maintained by chlorhexidine (0.12%) for 3 weeks (patients were recalled once a week in this period for supervising the compliance). Patients were then reinstructed in mechanical cleaning of the treated tooth. All patients were recalled once every 3 months until the final examination.

Statistical analysis

As there were no significant differences on any baseline parameter between maxillary and mandibular teeth, the statistical analysis were performed on subject level.

The categorical variables between the groups were analysed by using the Chi-square test. To compare continuous variables, Student *t*-test and Mann–Whitney *U*-tests were used.

The methods of ROC curve and the areas under curve (AUC) were used to present and/or compare the performances of the diagnostic tests. The ROC curves obtained the AUC and the maximum diagnostic discrimination cut-off point, which corresponded to the highest [(sensitivity+specificity)/2] value. The sensitivity (sen.) and specificity (spe.) of the diagnostic parameters were calculated and compared with the different parameter cut-offs.

To evaluate independent factors effecting final CRC a binary logistic regression model was applied. CRC (binary variable) was considered as dependent variable and AERSA (binary variable; <19 mm^2 low-group and ≥19 mm^2 high-group) and IPH (binary variable; <0.5 mm low-group and >0.5 mm high-group) and diagnostic groups (RT1 and RT2) were considered as independent variables in the model. As there were no ID-CAL and LPH values in RT1 group, these parameters were not included in regression model.

Statistical analyses were performed using the statistical package SPSS v 20.0** (IBM SPSS Statistics for Windows, Armonk, NY, USA). Values of $p < 0.05$ were considered statistically significant. The results are reported as mean ± standard deviation and number (*n*) and percent (%).

Results

A total of 126 patients were treated in the study without any unintended effects. Four patients did not comply with the control visits (three in RT1, one in RT2 group). The data of these drop-out patients were not included in the per-protocol statistical analysis. Therefore, the data of 122 defects were analysed (Table 1).

The baseline and 6th month values of the clinical parameters are summarized in Table 2. There were statistically significant reductions in GRD, GRW and AERSA parameters and gain in KT after 6 months following treatment both for RT1 and RT2 groups.

At the 6th month, MRC-UD scores were 97.7% and 95.1% for the RT1 and RT2 defects respectively ($p < 0.08$). In addition MRC-MD results were 99.4% for RT1 and 98.4% for RT2 groups ($p < 0.07$).

The ROC analysis was performed to determine the predictive baseline

Table 1. Baseline patient-related characteristics for RT1 and RT2 groups

	RT1 (*n* = 60)	RT2 (*n* = 62)
Age mean ± SD years	28.5 ± 5.6	28.0 ± 5.7
(range)	(20–42)	(20–41)
Gender *n* (%)		
Female	31 (51.7)	34 (54.8)
Male	29 (48.3)	28 (45.2)
Tooth *n* (%)		
Central Incisor	14 (23.3)	19 (30.6)
Lateral Incisor	29 (48.3)	27 (43.5)
Canine	17 (28.3)	16 (25.8)

$p < 0.05$ for all comparisons.

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Table 2. Clinical variables at baseline and 6th months follow-up

Variable	RT1 (n = 60) mean ± SD	RT2 (n = 62) mean ± SD	p
PD buc-B	1.3 ± 0.5	1.5 ± 0.6	0.108
PD buc-6	1.2 ± 0.4	1.4 ± 0.6	0.070
PD mes-B	1.2 ± 0.4	3.2 ± 0.8	0.0001
PD mes-6	1.1 ± 0.3	3.0 ± 0.9	0.0001
PD dis-B	1.3 ± 0.5	3.0 ± 0.8	0.0001
PD dis-6	1.2 ± 0.4	2.9 ± 0.8	0.0001
CAL buc-B	7.1 ± 1.3	7.5 ± 1.3	0.133
CAL buc-6	1.4 ± 0.5*	1.6 ± 0.5*	0.084
CAL mes-B	0	2.1 ± 0.6	–
CAL mes-6	0	1.9 ± 0.7	–
CAL dis-B	0	1.8 ± 0.7	–
CAL dis-6	0	1.7 ± 0.7	–
KT-B	1.6 ± 0.6	1.8 ± 0.7	0.127
KT-6	7.3 ± 0.9*	7.5 ± 1.2*	0.149
IPH mes-B	2.3 ± 0.6	1.1 ± 0.7	0.0001
IPH mes-6	2.3 ± 0.7	1.2 ± 0.7	0.0001
IPH dis-B	2.2 ± 0.6	1.2 ± 0.8	0.0001
IPH dis-6	2.2 ± 0.7	1.3 ± 0.8	0.0001
GRD-B	5.6 ± 1.3	6.0 ± 1.2	0.053
GRD-6	0.1 ± 0.4*	0.3 ± 0.6*	0.084
GRW-B	2.9 ± 0.8	3.1 ± 0.9	0.271
GRW-6	0.1 ± 0.3*	0.3 ± 0.5*	0.070
AERSA-B	15.8 ± 5.0	18.7 ± 5.9	0.010
AERSA-6	0.1 ± 0.4*	0.4 ± 0.9*	0.074
MRC-UD	97.7 ± 6.0	95.1 ± 9.1	0.080
MRC-MD	99.4 ± 1.6	98.4 ± 3.3	0.068

*$p < 0.05$ between baseline and 6th month in each group.

PD buc-B and PD buc-6, Buccal probing depth at baseline and 6 months; PD mes-B and PD mes-6, Mesial probing depth at baseline and 6 months; PD dis-B and PD dis-6, Distal probing depth at baseline and 6 months; CAL buc-B and CAL buc-6, Buccal clinical attachment loss at baseline and 6 months; CAL mes-B and CAL mes-6, Mesial clinical attachment loss at baseline and 6 months; CAL dis-B and CAL dis-6, Distal clinical attachment loss at baseline and 6 months; KT-B and KT-6, Keratinized Tissue at baseline and 6 months; IPH mes-B and IPH dis-B, Height of mesial and distal inter-dental papilla at baseline; IPH Mes-6 and IPH Dis-6, Height of mesial and distal inter-dental papilla at 6 months; GRD, gingival recession depth; GRW, Gingival recession width; AERSA-B and AERSA-6, Avascular exposed root surface area at baseline and 6 months; MRC-UD, Mean root coverage unidimensional; MRC-MD, mean root coverage multidimensional.

Table 3. Cut-off values and percentages of sensitivity, specificity obtained by ROC analyses

	Cut-off	Total %		RT1%		RT2%	
		Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
AERSA	19	0.83	0.82	0.88	0.94	0.81	0.67
IPH	0.5	1.00	0.32	1.00	0.60	1.00	0.00
	1.0	0.88	0.63	0.63	0.98	1.00	0.24
	1.5	0.79	0.89	0.37	0.99	1.00	0.78
	2.0	0.58	1.00	0.00	1.00	0.88	1.00
LPH	1.0	0.68	0.57	–	–	0.34	1.00
	1.5	0.92	0.53	–	–	0.83	0.99
	2.0	1.00	0.17	–	–	1.00	0.69
ID-CAL	0.5	0.67	0.53	–	–	1.00	0.00
	1.0	0.54	0.56	–	–	0.81	0.06
	1.5	0.38	0.69	–	–	0.56	0.35
	2.0	0.21	0.86	–	–	0.31	0.70

AERSA, Avascular exposed root surface area; IPH, Inter-dental papilla height; LPH, Loss of inter-dental papilla height; ID-CAL, Loss of inter-dental clinical attachment level.

cut-off points for AERSA, ICAL, IPH and LPH based on the endpoint parameter of CRC (Table 3 and Fig. 1). Sensitivity and specificity values were provided with regard to these cut-off points. The results showed that the baseline AERSA had a strong predictive value for achieving CRC in RT1 defects. The predictive cut-off point was 19 mm^2 (sens:88 spec:99). Although still valid, the baseline AERSA had less sensitivity and specificity values for 19 mm^2 (sens:81 spec:75) in RT2 group. Instead, IPH >2 mm (sens:88, spe:100) and LPH <1.5 mm (sens:83, spe:99) were found to be the strongest predictors for CRC in RT2 defects. The sensitivity and specificity of all cut-off ID-CAL values were not found to be acceptable for final CRC in RT2 defects.

The AERSA classification was developed based on 19 mm^2 with AERSA-L (low-risk subgroup, <19 mm^2) and AERSA-H (high-risk subgroup, ≥19 mm^2). The overall AERSA-H was 31.1% (38/122). This ratio was 16.7% (n = 10) for RT1 and 45.2% (n = 28) for RT2 group.

The overall CRC was 80.3% (98/122). While the CRC ratio was 86.7% (52/60) in RT1 defects; this percentage increased up to 98.0% in AERSA-L subgroup of RT1 defects (49 of 50). In addition, the remaining RT1 defects belonging to AERSA-H showed only %30.0 CRC (3 of 10). Similarly, the CRC rate was 74.2% (46/62) for RT2 group and this percentage increased up to 91.2% for AERSA-L subgroup (31 of 34), whereas AERSA-H defects showed 53.6% CRC (15 of 28). There were no significant differences between maxillary and mandibular recessions within RT1 and RT2 groups for MRC and CRC (p > 0.05).

Although univariate analyses showed that the group factor was not found to be an independent risk factor for CRC (Table 4); the results of logistic regression analyses indicated that to be in RT2 group (OR:15.0, 95%CI:1.3–175), AERSA ≥19 mm^2 (OR:23.7, 95%CI:5.0–111.6), IPH lower ≤1 mm (OR:97.3, 95% CI:9.5–988.1) were found to be independent risk factors related with not achieving final CRC (Table 5).

Discussion

The CAF+CTG technique is reported as the most effective procedure in terms of recession reduction in the treatment of Miller Class I and II (RT1) recessions. However,

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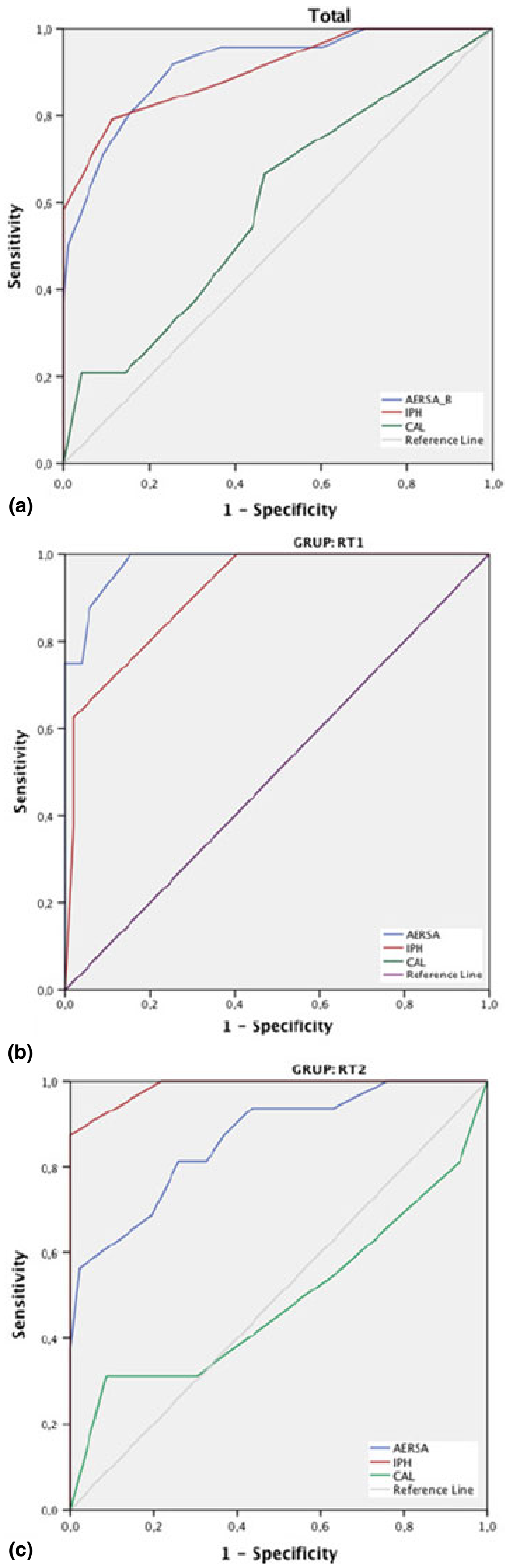

Fig. 1. The ROC analysis of avascular exposed root surface area, inter-dental papilla height and inter-dental clinical attachment level parameters for total (a), RT1 (b) and RT2 (c) groups.

even if the MRC achieved with CAF+CTG technique is highly significant, there is a great degree of inconsistency for the CRC outcome for these defects. The majority of previous studies of CAF+CTG included Miller Class I and II defects (RT1) with unpredictable CRC outcomes ranging between 18.1% (Da Silva et al. 2004) and 86.7% (Zucchelli et al. 2003) (Zucchelli & Mounssif 2015). Since a great variability in RC outcomes exists and data of CRC are always quite far from the desired 100%, further clinical studies are required for preventing diagnostic mistakes and determining the strongest combinations of presumed prognostic factors for RC (Zucchelli et al. 2006). Aichelmann-Reidy et al. (2001) suggested a subjective method based on periodontist's clinical experience but did not mention how the expected amount of RC was calculated. Zucchelli et al. (2006) presented a method to predict the maximum RC based on the calculation of the ideal height of the anatomic inter-dental papilla (Zucchelli et al. 2006). After 4 years, the same group evaluated the predictability of this method and reported that this procedure was able to predict the exact position of the soft tissue margin after mucogingival surgery in about 72% of the treated defects (Zucchelli et al. 2010). In addition, two important explorative studies by Cairo et al. (2011) and Pini-Prato et al. (2015) revealed that the evaluation of ICAL can be used to predict the final RC. Ozcelik et al. (2015) developed a prognostic model based on AERSA and gingival thickness and predicted the final RC after LPF in about 86% of treated defects. As clearly shown in the literature, there are evidence-based prognostic characteristics at baseline which may be considered as possible predictors for RC outcomes. Although these anatomic criteria present as independent diagnostic variables, their prognostic effect on RC seems as a result of interaction between them. Therefore, all four of possible predictors (IPH, LPH, ICAL and AERSA) were evaluated from a diagnostic and prognostic point of view in this study.

Complete root coverage was achieved in 86.7% of the RT1 defects. These findings are in accordance with

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Table 4. Results of univariate analyses for complete root coverage (CRC)

		None CRC		CRC		OR (95%CI) p
		n	%	n	%	
GROUP	RT2	16	66.7	46	46.9	2.7 (0.9–5.8)
	RT1	8	33.3	52	53.1	0.083
AERSA	>19	20	83.3	18	18.4	22.2 (6.8–72.9)
	<19	4	16.7	80	81.6	0.0001
IPH	0–1	19	79.2	11	11.2	30.1 (9.3–96.6)
	>1	5	20.8	87	88.8	0.0001

Table 5. Logistic regression analyses for complete root coverage

	B	p	OR	95% CI for OR	
				Lower	Upper
GROUP (RT2)	2.711	0.030	15.0	1.3	175.0
AERSA>19	3.168	0.0001	23.7	5.0	111.6
IPH≤ 1	4.578	0.0001	97.3	9.5	988.1

previous studies which range from 60% to 83% (Tatakis & Trombelli 2000, McGuire & Nunn 2003, Zucchelli et al. 2003, Cortellini et al. 2009, Cairo et al. 2012). Thus, it is clearly shown by the literature that CRC is not always achievable, even in GR with no loss of interproximal attachment and bone (Zucchelli et al. 2006). Therefore, other factors such as IPH, LPH, tooth rotation extrusion, CEJ abrasion and size of the recession area may limit the amount of RC (Aichelmann-Reidy et al. 2001, Bouchard et al. 2001, Zucchelli et al. 2006, Aroca et al. 2010, Ozcelik et al. 2015). This study indicated that the CRC percentage was up to 98% in AERSA-L subgroup of RT1 defects. In addition, the remaining RT1 AERSA-H defects showed only %30 CRC. This finding confirms the results of a recent clinical study which found that the baseline AERSA was strongly correlated with CRC in recession defects treated with LPF (Ozcelik et al. 2015). Similarly Bouchard et al. (2001) indicated that the size of the recession area does matter for RC. Therefore, it may be assumed that less RC may be expected for larger recession defect area even without ID-CAL. To clarify this issue, the AERSA distribution and its predictive specificity and sensitivity values in RT1 and RT2 defects were evaluated in this study. It was found that the baseline AERSA was strongly correlated with CRC and MRC in both RT1 and RT2 groups with the correlation being more significant in RT1 defects. Therefore, wide and deep RT I defects may have larger AERSAs than narrow and shallow RT2 defects and this may help to explain why RC results of some RT2 defects can be reported as better than RT1.

The univariate and multiple analyses which were performed to evaluate the effectiveness of CAF+CTG technique showed that the group type of the recession, baseline AERSA, IPH and LPH should be considered together for achieving CRC due to possible interaction between each other.

It is important to point out that IPH and LPH were more prominent than AERSA in RT2 defects (Fig. 2). This finding supports the results of a previous CAF+CTG study which treated single and multiple Miller Class I, II and III recessions (Zucchelli et al. 2010). The authors used a method to predict MRC based on the biologic and clinical concept that inter-dental papilla act as the most coronal vascular beds to which the soft tissues covering the root exposure are anchored at the time of the surgery. Similarly, Aroca et al. (2010) showed that CRC can be obtained in spite of a lack of inter-proximal bone support in multiple recession defects. The authors explained their finding with the presence of the support of the

Fig. 2. The baseline and 6 month photos of the RT2 defects with different avascular exposed root surface area, inter-dental papilla height and loss of inter-dental papilla height parameters.

gingival margin and papilla provided by the CTG, which may be slightly stretched in the inter-proximal spaces by the suspended sutures. In addition Saletta et al. (2001) also determined the significance of baseline dimensional features of the papilla and its relationship with RC and reported that CRC was correlated with height of inter-dental papilla in class I recession following CAF. Therefore, the statement of "every tooth with GR requires an ideal papilla, so that CRC can be accomplished" seems to be confirmed (Zucchelli et al. 2010). But it is also important to ask the question of how much inter-dental papilla height is required for RT1 and RT2

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defects to accomplish a CRC? In this study, the cut-off value for IPH was 1 mm. The logistic regression analyses of this study showed that IPH lower ≤1 (OR:97.3) was found to be related with not achieving final CRC. There is need for further studies to define the ideal papilla dimensions for different defect characteristics.

In regard of ICAL which was suggested as strong predictor of the final recession reduction (Cairo et al. 2011), there are some retrospective (Cairo et al. 2011) and clinical studies (Aroca et al. 2010, Cairo et al. 2012) which showed CRC in spite of ID-CAL. The RT2 defects with ID-CAL ≤3 mm were included in this study. While the overall CRC was 74.2% in RT2 group; this percentage increased up to 91.2% in AERSA-L subgroup of RT2 defects. These results were similar and even better than those reported for RT1 defects in the literature (Tatakis & Trombelli 2000, McGuire & Nunn 2003, Zucchelli et al. 2003, Cortellini et al. 2009, Cairo et al. 2012). Our findings were in accordance with a previous study by Cairo et al. (2012) which reported that the additional use of a CTG resulted in a greater number of sites with CRC, up to >80% of the sites, when the baseline amount of ID-CAL was ≤3 mm. The authors mentioned that efficacy of RC procedures in RT2 defects with minimal inter-dental loss of attachment could be similar to that in defects with no inter-dental loss of attachment (RT1). These findings may also mean that ID-CAL may be a potent prognostic factor at the level of 4 mm.

In the ROC analysis, the area under the ROC curves displayed very high values; furthermore, when the cut-off point for AERSA (19 mm^2) was selected in RT1 defects, specificity and sensitivity were 88% and 99% respectively. In a previous study (Ozcelik et al. 2015), the baseline AERSA cut-off value for achieving CRC after LPF was 15 mm^2. As expected, the additional use of CTG under CAF, led to an increase in the cut-off point to 19 mm^2.

In terms of graft size, it is well known that graft healing is affected by size of the CTG which is determined according to the avascular surface area dimensions. During the first healing phase, the connective tissue graft represents an obstacle to the nutritional exchanges between the periosteal beds lateral and apical to the bone dehiscence and the coronally advanced covering flap. The bigger the graft is, the greater the obstacle and the greater the risk of flap dehiscence and consequent graft exposure. Zucchelli et al. (2003) used the CTG size equal to or more than the bone dehiscence which means that the CTG dimensions were more than AERSA of the defect (Zucchelli et al. 2003). Therefore, the larger AERSA requires a bigger graft which may decrease the final CRC possibility. In addition, in a recent study Zucchelli et al. (2014), compared the CTG with reduced apicocoronal dimension (4 mm) with bigger CTGs and found no statistically significant differences in terms of CRC. Based on these findings, it may be concluded that the CRC result of CAF+CTG technique may not be affected by GRD but GRW seems to be one of the major factors.

In conclusion, within the limits of this study such as short-term (6 months) evaluation period and referral to a specific age population (20–42), the results have shown that CAF+CTG is an effective technique in the treatment of RT1 and RT2 (ID-CAL <3 mm) type isolated GRs and baseline AERSA and IPH variables seem to have strong predictive values for achieving CRC at the 6th month. These results should be confirmed in longer follow-up studies.

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Clinical Relevance

Scientific rationale for the study: No reports are available, evaluating the prognostic values of inter-dental papilla height (IPH), loss of IPH (LPH), avascular root surface area (AERSA) and inter-dental clinical attachment level (ICAL) for recessions without loss of ICAL (ID-CAL) (RT1) and with ID-CAL equal or smaller to the buccal attachment loss (RT2) for achieving complete root coverage (CRC).

Principal findings: AERSA ≥19 mm, IPH ≤1 mm, LPH >1.5 mm and to be in RT2 group may be accepted as risk factors related with not achieving CRC.

Practical implications: This study indicates that AERSA and IPH may provide strong predictive values for RT1 and RT2 defects with ID-CAL <3 mm.

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