Evaluation of Root Coverage With and Without Connective Tissue Graft for the Treatment of Single Maxillary Gingival Recession Using an Image Analysis System: A Randomized Controlled Clinical Trial

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The aim of this prospective randomized clinical study was to evaluate, by means of an image analysis system, the efficacy of two different surgical procedures for the treatment of Miller Class I and II maxillary gingival recession. Patients treated for maxillary gingival recession were recruited and randomly divided into two groups: patients who received a coronally advanced flap with connective tissue graft (CAF + CTG) or CAF alone. Outcome parameters included complete root coverage, recession reduction, and keratinized tissue amount. Twenty-five patients completed the 12-month follow-up period. Patients in the CAF + CTG group showed a better primary outcome—gingival recession at 12 months—than CAF patients (P = .0001). Gingival recession at 12 months had a median of 0.5 (interquartile range [IQR] 0.5 to 0.6) in the CAF + CTG group and a median of 1.0 (IQR 0.9 to 1.1) in the CAF group. CAF + CTG and CAF groups had similar complete root coverage at 6 and 12 months. Recession and keratinized tissue width significantly decreased over time (P < .0001), with no effect of treatment or of treatment over time. Buccal probing depth had similar values over time (P = .28) and in the two groups (P = .52). Buccal clinical attachment level had similar values in the two groups (P = .87); moreover, mesial and distal clinical attachment levels did not show any variation over time (P = .88 and P = .68, respectively). By means of a computerized image analysis system better outcomes in terms of recession reduction after 12 months of follow-up were measured for maxillary gingival recessions treated with CAF and CTG. Adjunctive application of a CTG under a CAF increased the probability of achieving complete root coverage in maxillary Miller Class I and II defects (61.5% versus 83.3%; P = .38). Both treatments were equally effective in providing a consistent reduction of the baseline recession. (Int J Periodontics Restorative Dent 2015;35:247–254. doi: 10.11607/prd.2241)

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Numerous surgical techniques have been introduced over the years to correct labial gingival recession defects. Esthetic concerns are usually the reason to perform these procedures.[1]

Perhaps the most widely used surgical procedures by clinicians for root coverage are the coronally advanced flap (CAF) and CAF performed in conjunction with connective tissue graft (CTG). In CAF procedures, the gingival flap is

raised beyond the mucogingival junction (MGJ), and, because of the elasticity of the alveolar mucosa along with periosteal releasing incisions, the flap can be stretched in a coronal direction to cover the exposed root surfaces.[2,3] In CAF + CTG (bilaminar technique) procedures,[4–6] the CAF is used to cover the harvested CTG, thereby enabling the graft to receive dual blood supply from periosteum and the flap itself.[7]

Systematic reviews have examined the effectiveness of CAF versus CAF + CTG at covering exposed root surfaces at gingival recession sites.[8–12] The first randomized controlled trial (RCT) comparing CAF and CAF + CTG showed no significant with respect to reduction in recession depth at 6 months.[9] On the other hand, a multi-center, double-blinded RCT involving 85 patients demonstrated CAF + CTG's superiority over CAF alone in achieving complete root coverage (CRC) in maxillary Miller Class I and II recession defects at 6 months. The odds of obtaining CRC were 5.09 times greater with the additional use of a graft as opposed to performing the CAF alone.[11] A recent Cochrane systematic review reported that the use of CAF + CTG is the most effective periodontal plastic procedure in obtaining root coverage.[12]

To date, root coverage outcomes of most clinical studies were reported in changes of recession depth (RD) and clinical attachment level (CAL) measured with conventional periodontal probes. However, measurements made with manual periodontal probes were subject to errors arising from difficulties in localizing cementoenamel junctions (CEJs)[13] and inaccuracy of periodontal probing.[14] Recently, image analysis systems such as ImageJ[15] have been utilized as more objective and accurate methods of quantifying the parameters measured in root coverage studies. The validity and reproducibility of ImageJ analysis has been shown to be reliable in evaluating the percentage of root coverage.[16] The aim of this study was to compare the effectiveness of root coverage with CAF alone versus CAF + CTG in the treatment of single gingival recessions by analyzing the data with an open source image-processing program.

Method and materials

Patient selection

Treatments were performed between February 2012 and January 2013 at the Dental Clinic of Biomedical Sciences Institute, University of Padua, Padua, Italy. The study protocol was approved by the Institutional Review Board (ref. nos. 399/2010 and 1387/2010).

Informed consent was obtained from all of the participants included in the study for treatment of single maxillary recessions. The study protocol was carried out in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki, as revised in 2000.

Twenty-eight patients who received CAF + CTG or CAF alone were included in this retrospective study. Two randomized groups were considered: 14 patients treated with CAF and 14 with CAF + CTG.

To detect a mean difference of gingival recession at 12 months between the two groups of 0.5 mm with an SD of 0.5 mm, setting a power of 0.80 and an alpha of .05, a minimum sample size of 14 patients per group was estimated.[17]

Inclusion criteria were as follows: *(1)* single gingival recession in the anterior maxilla with esthetic problems and/or dental hypersensitivity (second premolar, canines, and incisors); *(2)* absence of local inflammation; *(3)* no active periodontal disease with no site showing probing depth (PD) > 4 mm; *(4)* smoking ≤ 10 cigarettes per day; *(5)* Full-Mouth Plaque Score (FMPS) and Full-Mouth Bleeding Score (FMBS) ≤ 15% (measured at four sites per tooth); *(6)* presence of at least one Miller Class I or II buccal gingival recession ≥ 2 mm of depth; *(7)* presence of an identifiable CEJ; *(8)* no history of mucogingival or periodontal surgery at the experimental site.

Exclusion criteria were teeth presenting with root steps (abrasion, abfraction, or erosion) > 1 mm at the CEJ level or with crowns or restorations at the CEJ level.

Each selected patient contributed a single gingival recession. If patients presented multiple recessions, the deepest one was selected.

Presurgical procedures

All participants received a session of prophylaxis after the screening examination; instruction in proper

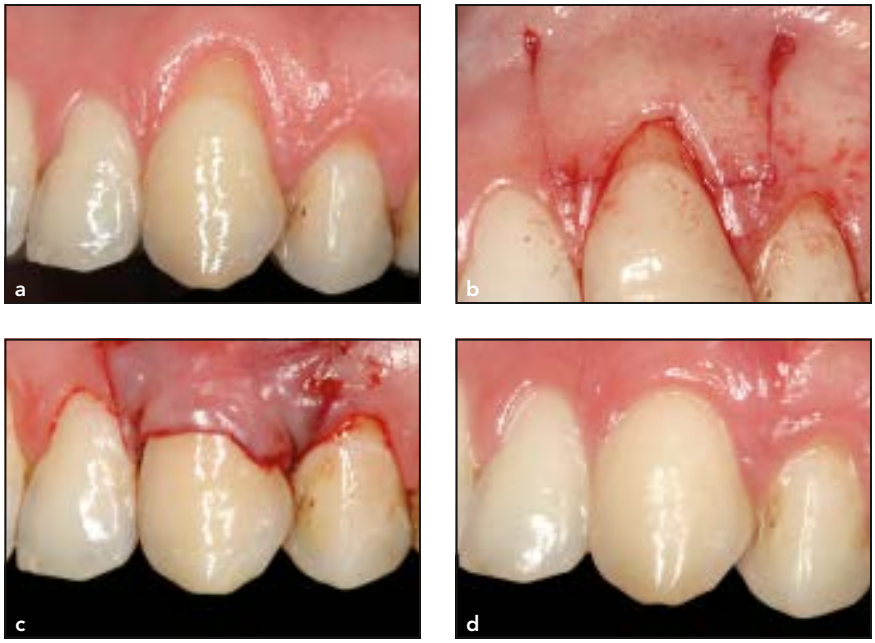

Fig 1 *Single Miller Class I buccal recession.* (a) *Frontal aspect.* (b) *Double oblique releasing incisions.* (c) *Soft tissue coronal replacement without connective tissue graft.* (d) *Healing 6 months after surgery.*

oral hygiene measures, supragingival scaling, and professional tooth cleaning with the use of a rubber cup and a low abrasive polishing paste were provided. In order to minimize tooth-brushing trauma to the gingival margin, a coronally directed roll technique was prescribed for teeth with recession-type defects. All clinical measurements were carried out by a single masked examiner (DL) at baseline, 6 months, and 1 year after the surgery. DL did not perform surgery and was unaware of the treatment assignment. The examiner was calibrated before the study to reduce intra-examiner error (κ 38.75) in reliability and consistency. All surgeries were performed by the same experienced clinical periodontist, specifically trained and calibrated to perform the tested surgical approaches.

FMPS was recorded at four aspects per tooth to reveal the presence of plaque.

Surgical procedure

The control group was treated with CAF alone (Fig 1), whereas the test group received CAF + CTG (Fig 2). One operator performed all surgical procedures. After local anesthesia, two divergent releasing incisions were performed beyond the MGJ. An intrasulcular incision was performed at the buccal aspect of the selected tooth. A split-thickness surgical papillae was then raised while a full-thickness flap until the MGJ was elevated; beyond the MGJ, a partial-thickness flap was raised so that any residual tension was eliminated and a passive coronal flap displacement was achieved. Root debridement was performed with a sharp curette. The papillae adjacent to the recipient site were de-epithelialized.

The randomization was applied at this time and the clinician was instructed whether or not to perform a CTG under the flap. The randomized treatment code (CAF or CAF + CTG) was available in closed, non-transparent envelopes that were opened after flap elevation.

In the test group, a 1- to 2-mm-thick CTG was harvested using a single incision approach from the palate in the area between the second premolar and the first molar.[4]

The graft was positioned on the instrumented root surface immediately apical to or at the level of the CEJ. Graft stabilization was performed by using a compressive

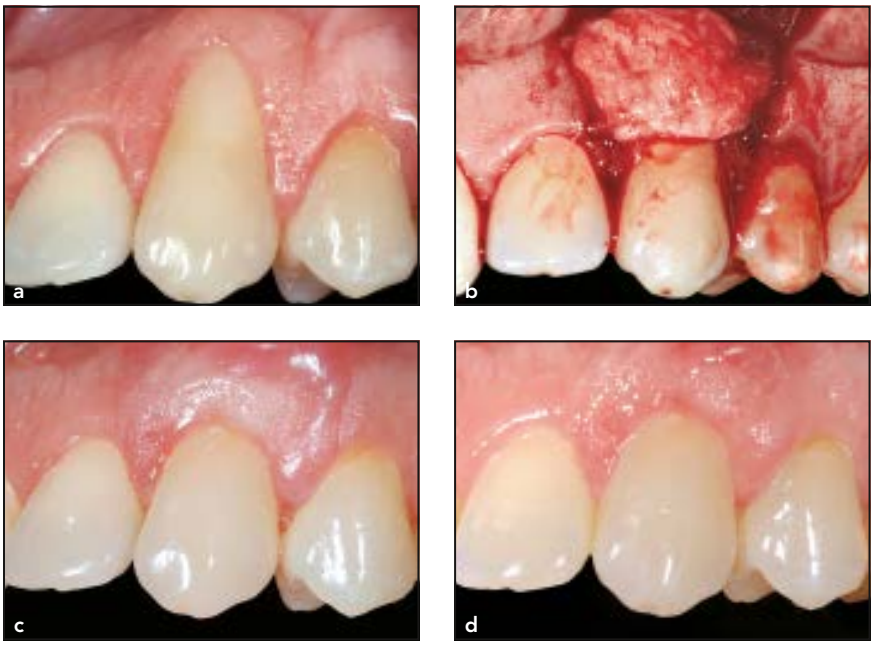

Fig 2 *Single Miller Class I buccal recession.* (a) *Frontal aspect.* (b) *Double oblique releasing incisions and connective tissue graft stabilization.* (c) *Healing 6 months after surgery.* (d) *Healing 12 months after surgery.*

crossing suture, anchored to the periosteum apical to the graft (Monocryl 6-0 P-3 needle, Ethicon, Johnson & Johnson). The flap was coronally displaced 1 to 2 mm above the CEJ in both the test and control groups. A sling suture was placed to stabilize the flap in a coronal position, followed by interrupted sutures on the releasing incisions with an apicocoronal direction, using Monocryl 5-0 sutures.[4]

For 2 weeks following the treatments, patients were instructed to avoid any mechanical trauma and tooth brushing. Chlorhexidine rinses were prescribed twice daily for 1 minute. Seven days after surgery, sutures were removed and prophylaxis was performed. Two weeks after surgery, patients were instructed to start mechanical tooth cleaning by using a soft toothbrush. Patients were recalled 3 and 6 months after surgery for professional oral hygiene procedures and measurements.

Parameters analyzed

The buccal gingival margin modification was the main clinical parameter investigated. A computerized analysis (ImageJ image processing software, National Institutes of Health) was performed for the photograph measurements.[16,18] In order to avoid any image distortion, a frontal projection was used, and two setting parameters were chosen to check the reproducibility of each picture (Fig 3). They were *(1)* apicocoronal vertical line (a) from the most apical point of the buccal gingival margin to the most coronal portion of the crown edge; and *(2)* a mesiodistal horizontal line (b) at the widest part of the crowns adjacent to the treatment site. One of the teeth adjacent to the treatment site was used for a and b measurements. A calibrated plastic probe (TPS probe, Vivadent) was used on the same tooth to compare the values of a and b with those measured with the computerized analysis. For data calculation, only differences of ≤ 0.5 mm were accepted. The photographs were taken using a Canon 30D SLR camera with a 100-mm macrolens and Canon ring flash. The photographs were taken at a proportion of 1.5:1 with a 100-shutter speed and 14F stop in manual mode.

Four lines were drawn on each photograph to measure the gingival

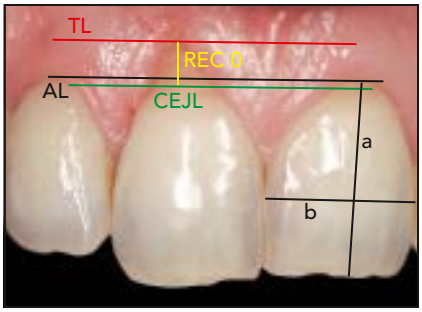

Fig 3 *Measurement of the gingival recession before treatment. A guideline (AL) joins the most apical point of the buccal margin of the teeth adjacent to the treatment site; a second line (TL) parallel to AL indicates the most apical point of the test site buccal margin; a third line (CEJL) parallel to AL joins the CEJ of the tooth needing treatment; a fourth line (REC 0) measures the recession of the gingival margin.* (a) *Apicocoronal vertical line and* (b) *the mesiodistal horizontal line of the adjacent tooth were chosen as setting parameters to check the reproducibility of each picture.*

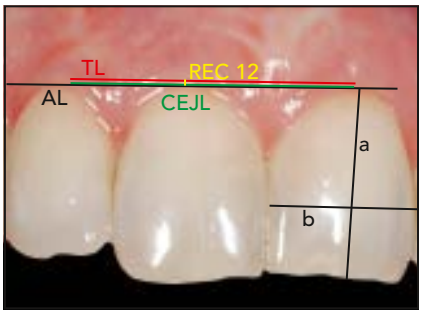

Fig 4 *Measurement of the gingival recession reduction 12 months after treatment. A guideline (AL) joins the most apical point of the buccal margin of the teeth adjacent to the treatment site; a second line (TL) parallel to AL indicates the most apical point of the test site buccal margin; a third line (CEJL) parallel to AL joins the CEJ of the tooth needing treatment; a fourth line (REC 12) measures the recession of the gingival margin.* (a) *Apicocoronal vertical line and* (b) *the mesiodistal horizontal line of the adjacent tooth were chosen as setting parameters to check the reproducibility of each picture.*

margin modification on the treated tooth: a guideline (AL) was drawn joining the most apical point of the gingival margin of the teeth adjacent to the treatment site; a second line (TL), parallel to AL, was used to indicate the most apical point of the gingival margin at the recession site; a third line (CEJL), parallel to AL, was drawn joining the CEJ of the treated tooth; finally, a fourth line (REC) measured the distance between TL and CEJL. The difference between REC before treatment (REC 0) and at baseline (REC B), after 6 (REC 6) and 12 months (REC 12) of follow-up, measured the recession reduction (RECred) of the gingival margin (Figs 3 and 4). Only apical shrinkage of ≥ 0.5 mm was considered as soft tissue recession. The RECred variable was assessed for each patient at the following time points: after treatment and after 6 and 12 months of follow-up. In order to evaluate the modification of the gingival margin, digital photographs were taken at time points for each patient, respectively.

Measurements were made at the mesial and distal aspect of each tooth and were reported in millimeters. Measurements were taken by one of the authors (DL) and rounded off to the nearest half-millimeter.

Any adverse event or biologic or technical complication was recorded if present at any time point.

Statistical analysis

Continuous data were expressed as median and interquartile range (IQR) because Shapiro test rejected the hypothesis of normal distribution of data for all continuous variables (not reported in Results). Categorical data were compared between the two groups using the Fisher test, whereas continuous data using the Mann-Whitney test. Gingival recession at 12 months (primary outcome) was compared between the two groups using a one-sided Mann-Whitney test. Variables recorded at three different time points (baseline, 6 months, 12 months) were analyzed using Friedman two-way nonparametric analysis of variance, including time, group, and the interaction time/group in the model. A *P* value less than .05 was considered statistically significant. Statistical analysis was performed using R 2.12 language.

Table 1 Study demographics (n) and results (median)

	Coronally advanced flap (CAF) group (n = 13)	CAF + connected tissue graft (CTG) group (n = 12)
Tooth		
Central incisor	2	0
Lateral incisor	1	1
Canine	6	6
Premolar	4	5
Complete root coverage (CRC) 6 mo: yes*	9 (69.2%)	10 (83.3%)
CRC 12 mo: yes*	8 (61.5%)	10 (83.3%)
Recession depth (mm)†		
Baseline	3.1 (2.9–3.3)	2.9 (2.8–3.0)
6 mo	0.9 (0.7–1.1)	0.5 (0.5–0.6)
12 mo	1.0 (0.9–1.1)	0.5 (0.5–0.6)
Keratinized tissue (mm)†		
Baseline	2.6 (2.5–2.7)	2.5 (2.4–2.6)
6 mo	2.9 (2.9–3.0)	2.8 (2.7–2.9)
12 mo	3 (2.9–3.0)	2.8 (2.7–2.9)
Probing depth buccal (mm)‡		
Baseline	1.5 (1.5–1.5)	1.5 (1.0–1.5)
6 mo	1.5 (1.0–1.5)	1.0 (1.0–1.5)
12 mo	1.0 (1.0–1.5)	1.0 (1.0–1.5)
Clinical attachment level (CAL) buccal (mm)*	4.5 (3.9–4.8)	4.5 (3.9–4.7)
CAL mesial (mm)‡		
Baseline	2.1 (2.0–2.3)	2.5 (2.3–2.8)
6 mo	2.2 (2.0–2.3)	2.5 (2.3–2.7)
12 mo	2.1 (1.9–2.3)	2.5 (2.3–2.7)
CAL distal (mm)‡		
Baseline	2.5 (2.3–2.8)	2.5 (2.3–2.8)
6 mo	2.5 (2.3–2.7)	2.5 (2.3–2.7)
12 mo	2.4 (2.3–2.6)	2.5 (2.2–2.6)

Data expressed as n (%) or median (interquartile range).
*Similar between the two groups.
†Affected only by time.
‡Not affected by group, time, or their interaction.

- Patients in the CAF + CTG group showed a better primary outcome—gingival recession at 12 months—than CAF patients ($P = .0001$, one-sided test). In fact, gingival recession at 12 months had a median of 0.5 (IQR 0.5 to 0.6) in the CAF + CTG group and a median of 1.0 (IQR 0.9 to 1.1) in the CAF group.
- CAF + CTG and CAF groups had similar CRC at 6 (69.2% versus 83.3%, respectively, $P = .64$) and 12 months (61.5% versus 83.3%, respectively, $P = .38$).
- REC significantly decreased over time ($P < .0001$), with no effect of treatment or of treatment over time ($P = .31$ and $P = .61$, respectively).
- Keratinized tissue (KT) significantly increased over time ($P < .0001$), with no effect of treatment or of treatment over time ($P = .45$ and $P = .14$, respectively).
- Probing depth buccal (PD BUC) had similar values over time ($P = .28$) and in the two groups ($P = .52$).
- CAL BUC, had similar values in the two groups ($P = .87$); moreover, CAL mesial (CAL MES) and CAL distal (CAL DIST) did not shown any variation over time ($P = .88$ and $P = .68$, respectively).

Results

Twenty-five patients (11 men, 14 women, mean age: 46 years) were treated and completed the 12-month follow-up period. Three patients could not be reached after the surgical treatments, so they were considered drop-outs: two of them were included in the CAF + CTG group, while one was included in the CAF group.

All numerical values are reported in Table 1.

No significant differences were calculated for the group between measurements during different follow-up visits.

Discussion

The present RCT was designed to test the added clinical benefit, in terms of root coverage, of the placement of a CTG under a CAF in the treatment of Miller Class I and II single gingival recessions.

ImageJ software analysis was used in the present RCT to compare the effectiveness of root coverage. The 1-year follow-up results showed in patients in the CAF + CTG group a better primary outcome—gingival recession at 12 months—than in CAF patients and a greater number of treated sites with CRC in patients receiving CAF + CTG than in those receiving CAF alone, even if this last result was not statistically significant (Table 1). Patients receiving CAF + CTG did not exhibit more gain in keratinized tissue at 1-year compared to those receiving CAF alone (Table 1).

Both the test and the control procedures were effective in reducing the recession depth; 0.5 mm greater recession reduction was observed in the cases treated with the CTG technique (Table 1), but this difference did not reach statistical significance. These data confirmed the outcomes of a previous small sample controlled study[9] and are consistent with a multicenter, double-blind clinical trial published by Cortellini et al.[11] As reported in those studies, sites treated with CAF + CTG showed improved clinical outcomes with respect to CAF alone, but the difference did not reach statistical significance. In the present clinical trial, however, the adjunctive application of a CTG under a CAF increased the probability of achieving CRC in Miller Class I and II defects (61.5% versus 83.3%, $P = .38$).

The authors' results are comparable with data reported by several authors[8,9,11,19]; therefore, ImageJ software analysis, which was used in the present study, has been shown to be a reproducible and reliable method in assessing the percentage of root coverage.[16] This software has already been utilized for several publications regarding tooth anatomy, mucogingival surgery, and peri-implant soft tissue analysis.[16,19–21]

Clinical measurements with periodontal probes may be less precise than ImageJ measurements because rounding of numbers in clinical measurement may lead to a greater percentage of variation errors than making measurements using digital image pixels with ImageJ software.[16] In fact, from different publications,[16,19–21] it may be assumed that the risk of error with ImageJ is less important than with the standard clinical measure. As Kerner et al reported in two papers, a typical value of the clinical recession depth is 4 mm.[16,19] This value is rounded to the nearest millimeter. This corresponds to a potential 25% error of variation of the measurements. With ImageJ, the corresponding potential error for recession depth = 4 mm is 1/330 pixels, corresponding to 0.003%. It may be considered that clinical measurements are less precise than the ImageJ measurements. One can assume that the use of a custom stent to perform clinical measurements may improve the accuracy of the results. However, very few root coverage studies use this device (stent) for clinical parameters assessment. The reason may be the lack of evidence in the literature showing an advantage in the use of acrylic stents compared with standard clinical measurements in the specific evaluation of recession depth.

The ImageJ analysis provided a simple and reliable method of quantifying root coverage without the need for complex devices. It was a useful, fast, sensitive technique, and can be advised for clinicians and researchers in the evaluation of the percentage of root coverage.

Nevertheless, the accuracy of ImageJ evaluations heavily depends on the quality of the digital photographs. Poor quality photographs cannot be analyzed due to the difficulty in defining the CEJ location. It may be assumed that the use of a digital camera would improve the image analysis and reproducibility. Taking photographs from slightly different angulations may lead to distortion of the actual dimensions of the measured structures, which may result in less precise measurements. In addition, ImageJ evaluation itself does not allow recordings of absolute number of measured parameters unless a caliber such as a periodontal probe is also included in the photograph so clinicians can measure the parameters (eg, recession depth) by comparing the image pixels to the actual dimension of a periodontal probe. Despite these drawbacks, the ImageJ analysis is an easy and reliable method in quantifying root coverage

following periodontal plastic procedures. It is objective and may provide an image database for future research.

Conclusions

Within the limit of this study, the following conclusions can be drawn:

1. The treatment of maxillary gingival recession with CAF + CTG showed a better primary outcome than CAF alone in terms of recession reduction after 12 months of follow-up.
2. Both treatments are equally effective in providing a consistent reduction of the baseline recession.
3. The use of a computerized image analysis system may be a simple and reliable way to measure the soft tissue modifications during a follow-up period.

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