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ORIGINAL ARTICLE

Comparison between a xenogeneic dermal matrix and connective tissue graft for the treatment of multiple adjacent gingival recessions: a randomized controlled clinical trial

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Abstract

Aim To compare the outcomes of modified coronally advanced flap (mCAF) combined with either xenogeneic dermal matrix (XDM) or connective tissue graft (CTG) for the treatment of multiple adjacent gingival recessions (MAGRs).

Materials and methods Forty-two patients, in whom 130 maxillary (MAGRs) of type (RT1) were found, were randomly allocated to the two groups. Clinical, esthetic, and patient-centered outcomes were evaluated at baseline, 6, and 12 months post-treatment.

Result Group CAF+ CTG exhibited a higher mean root coverage value (mRC) (91.79%) (primary outcome variable) than group CAF+XDM (80.19%) without statistically significant difference at 12 months ($p=0.06$). The control group also had significantly higher percentage of teeth in which complete root coverage (CRC) and mean gain of gingival thickness (GT) were achieved, than the test group ($p<0.05$). With respect to patient-centered outcomes, patients of the test group reported having experienced significantly less pain than those of the control group until 7 days ($p<0.05$). Both surgical approaches were capable of significantly decreasing dentin hypersensitivity ($p<0.05$). No difference between groups was found in the esthetic score analysis ($p>0.05$). Mean surgical time was lower in the test group ($p<0.05$).

Conclusion The two treatments showed similar mRC. However, CAF+CTG was superior to CAF+XDM in providing CRC and in gaining GT. CAF+XDM demonstrated advantages over CAF+CTG with regard to patient morbidity and surgical time.

Clinical relevance Application of XDM provided a better patient experience and shortened the time to recovery after coronally advanced flaps for coverage of multiple adjacent recessions. However, CTG resulted in improved percentages of complete root coverage.

Trial registration Brazilian Clinical Trials Registry (REBEC) number: RBR-974c9j

Keywords Gingival recessions · Coronally advanced flap · Connective tissue graft · Acellular dermis

Introduction

Gingival recession (GR), a pathological migration of the gingival margin in an apical direction beyond the cemento-enamel junction, has a multifactorial etiology [1]. Several surgical techniques have been proposed for the treatment of GR in order to provide root coverage, with long-term, stable, functional, and esthetic outcomes and minimal morbidity [2–4].

The coronally advanced flap (CAF) has been suggested as an effective therapeutic approach for the treatment of multiple gingival recessions [5, 6]. According to systematic reviews that have compiled data from studies that compared different surgical techniques for root coverage, the connective tissue graft (CTG) associated with CAF is the "gold standard" in

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terms of clinical outcomes of multiple GRs. CAF + CTG are able to yield the best results in terms of mean/percentage of root coverage and percentage of teeth in which complete root coverage (CRC) is achieved [7, 8]. Nevertheless, several drawbacks have also been associated with harvesting a CTG, such as patient morbidity, prolonged intra- and post-operative bleeding, palatal sensory dysfunction, infection, and an increased surgical time [9, 10].

In the last decades, clinicians and researchers have been seeking suitable alternative methods, such as allograft or xenograft materials, to treat GR, as these are less invasive, do not involve a second surgical site, and provide satisfactory rates of root coverage [11]. In this context, the use of collagen-based xenogeneic matrices has been considered a valid substitute for the CTG in the treatment of GR, yielding promising clinical outcomes with the advantage of lower levels of patient morbidity, as no second surgical site is required [5, 12–15].

Recently, a xenogeneic dermal matrix (XDM) porcine-derived acellular collagen matrix, composed of three-dimensional type I/III collagen matrix (Mucoderm®, Botiss biomaterials, Germany), has been proposed as a soft tissue graft substitute and a possible alternative to CTG in mucogingival surgeries. When analyzed by scanning electron microscopy, this biomaterial shows a collagen arrangement with pores that allow vascularization and provide a framework for connective tissue cell migration [16]. In addition, the matrix thickness acts as a space maintainer favoring the formation of keratinized tissue [17]. Therefore, the aim of the study was to compare clinical and patient-centered outcomes of CAF with either XDM or CTG in the treatment of maxillary MAGRs type I over a follow-up period of 12 months.

Materials and methods

Trial design

The present study was a parallel, randomized, single-center controlled clinical trial. The study was conducted according to the CONSORT statement (http://www.consort-statement.org/). The study protocol was approved by Guarulhos University Board (approval 2.290.510) and registered on *ensaiosclinicos.gov.br* (Identifier number: RBR-974c9j). Informed consent was obtained from all eligible patients. The study was conducted in compliance with the principles outlined in the Declaration of Helsinki on experimentation involving human subjects, as revised in 2013.

Participants

Eligible patients were recruited from a pool of patients seeking root coverage treatment at the Dental Clinic of Guarulhos University (Guarulhos, SP, Brazil) between December 2017 and September 2018. The last follow-up visit (at 1 year) was completed in March 2020. Participants were selected based on the following inclusion and exclusion criteria:

Inclusion criteria

- Age ≥18 years;
- Full-mouth plaque score (FMPS) and full-mouth bleeding score (FMBS) ≤ 20% (probing of four sites per tooth);
- Presence of recession type (RT1) (no loss of interproximal attachment and no interproximal CEJ clinically not detectable from both mesial and distal aspects; Cairo et al. [18]) gingival recessions with a depth of ≥ 2 mm in at least 2 adjacent maxillary non-molar teeth;
- Esthetic complaints and/or dental sensitivity associated with the gingival recessions;

Exclusion criteria

- Systemic diseases, pregnancy, and breast-feeding;
- History of periodontitis;
- Current smoking;
- Gingival recessions with <1mm of keratinized tissue apically;
- History of mucogingival or periodontal surgery at experimental sites;
- Non-carious or carious cervical lesions

Sample size

The sample size was calculated using $\alpha = 0.05$, a power (1-β) of 80%, a standard deviation (SD) of 0.46 mm for reduction in recession, as described in a previous study [12], and a minimal clinically important difference of 0.5 mm between groups for reduction in recession. Based on these values, it was determined that 18 patients should be included in the test group (CAF+XDM) and 18 in the control group (CAF+CTG). However, the number of patients per group was increased by 15% considering the possibility of dropouts.

Randomization/allocation concealment/blinding

The randomization of the patients was performed by using a computer-generated randomization table prepared by an investigator with no clinical involvement in the trial (JG). Allocation concealment was obtained by using a sealed coded opaque envelope containing the treatment for the specific subject. The envelope with the patient's allocation was only opened during the surgery after flap elevation. The examiner was blinded to the treatment assignment throughout the entire period of the study.

Interventions/operator/investigators

Pre-surgical phase

All participants underwent a comprehensive periodontal examination performed by a single calibrated examiner (JMM). Prior to surgical therapy, all patients received dental hygiene instructions on how to perform non-traumatic toothbrushing and professional dental cleaning (supragingival scaling/debridement and polishing).

Surgical procedure

A single operator (MF), with over 10 years of experience in mucogingival surgery, performed all the surgical interventions. A split-full-split thickness flap envelope flap was raised, without performing vertical incisions, as previously described by Zucchelli and De Sanctis [6]. After flap elevation, all exposed root surfaces were mechanically treated with manual curettes, avoiding the connective attachment area near the bone crest.

At this point of the surgical procedure, the sealed envelopes that had concealed the patients' (individual) treatment allocation data were opened. In the test group, the XDM (Mucoderm®, Botiss biomaterials, Germany) was prepared and carefully placed onto the root recessions, according to the manufacturer's instructions. In the control group, CTG was harvested from the palate using the 1.5-mm double-blade technique, as previously described by Harris [19]. Both XDM and CTG were sutured on the interdental papilla with absorbable sutures. The flap was then coronally displaced and sutured with nonabsorbable sutures, approximately 1–2 mm above the CEJ, in both test and control groups. The procedures performed in the test and control groups are illustrated in Figs. 1 and 2.

Post-operative care

Pain was controlled with 600 mg ibuprofen; patients were instructed to take one tablet at the end of the procedure, one 6 h later, and to continue as needed for pain. Study participants were instructed to use chlorhexidine mouth rinse (0.12%) twice daily for 2 weeks. No toothbrushing was allowed in the treated area for 14 days, and thereafter patients were instructed to use only ultrasoft toothbrushes. Patients were re-evaluated at 14 days after surgery, when sutures were removed. Oral hygiene instruction was given at baseline, 6, and 12 months post-surgery.

Outcomes

The main aim of this RCT was to compare CAF+XDM (test group) with CAF+CTG (control group) for the treatment of MAGRs in the maxilla. Based on a hypothetical no-inferiority effect of the XDM (test group), the following endpoints were considered:

1. Primary endpoint: mean root coverage (mRC) GR 0−GR 12/GR 0 × 100% at 12 months post-treatment.

Secondary endpoints:

1. Mean reduction in GR
2. Percentage of teeth in which CRC was achieved;
3. Gingival thickness;
4. Recession width;
5. Keratinized tissue width;

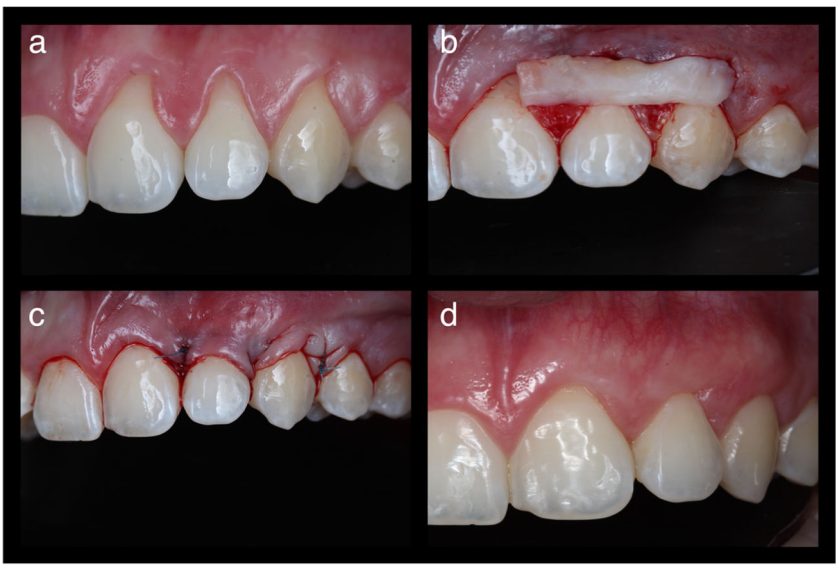

Fig. 1 The surgical procedure in the connective tissue graft (CTG) group. **a** Baseline view of multiple gingival recession. **b** Intraoperative view connective tissue graft harvested from palate. **c** Flap sutured with a sling suture. **d** Clinical aspect at 12 months of follow-up

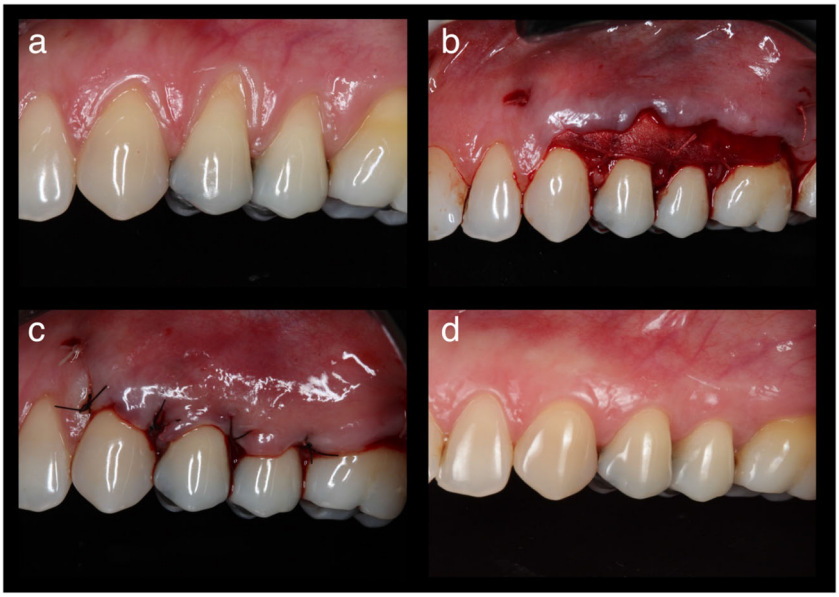

Fig. 2 The surgical procedure in the xenogeneic dermal matrix (XDM) group. **a** Baseline view of multiple gingival recession. **b** XDM stabilization with simple suture. **c** Flap sutured with a sling suture. **d** Clinical aspect at 12 months of follow-up

6. Patient-reported outcomes (the dentin hypersensitivity, esthetic, and quality of life evaluation
7. Surgical time;
8. Professional esthetic outcomes (Root-Coverage Esthetic Score (RES)).

Examiner calibration

One calibrated examiner (JMM) performed all periodontal measurements. An intra-rater agreement study was performed for GR height. A set of 15 recessions were evaluated twice with a 2-h interval between evaluations. The examiner demonstrated intra-class correlation coefficient of 0.87 for GR height (CI 95% 0.85; 0.92) and of 0.81 (95% CI: 0.65; 0.88) for gingival thickness (GT).

Periodontal clinical measurements

A stent was fabricated from and impression of the maxilla poured in a stone cast. A groove was made on the stent at the mid-buccal area of the experimental tooth to allow reproducible positioning of the periodontal probe. All periodontal measurements were recorded before surgery (at baseline) and at time intervals of 6 and 12 months after the root coverage procedures. A single calibrated and masked examiner (JMM) recorded the following variables on the mid-buccal surfaces of the teeth selected, using a manual periodontal probe (PCP UNC 15, Hu-Friedy):

1. GR height (GR) — distance from the CEJ to the free gingival margin (mm);
2. Recession width (RW) — distance from distal to mesial gingival margin at the CEJ level (mm);
3. Probing pocket depth (PPD) — distance from the gingival margin to the bottom of the sulcus (mm);
4. Clinical attachment levels (CAL) — distance from the CEJ to the bottom of the sulcus (mm);
5. Keratinized tissue width (KTW) — distance from GM to the mucogingival junction visualized with the use of Lugol's iodine staining (mm);
6. GT — At baseline was measured 1.0 mm apical to MG using an injection needle, perpendicular to tissue surface, and a silicon stop on the gingival surface. After removing the needle, the distance between the needle tip and silicon stop was estimated using a digital caliper [20];
7. Bleeding on probing (BOP) — presence/absence of bleeding after sulcus probing Ainamo & Bay 1975 [21];
8. Plaque Index (PI) — recording the presence/absence of plaque on buccal tooth surface Ainamo & Bay 1975[21]

Surgical time

Duration of the surgery (in minutes) was timed from the first incision to the last suture.

Esthetic evaluation by a clinician

The Root-Coverage Esthetic Score (RES) was used to evaluate esthetics at 6-month and 12-month follow-up time intervals, as previously reported by Cairo et al. [22]. The final RES value ranged from 0 to 10, with 10 being the best esthetic score. Standardized photographs of treated GR sites from baseline, 6, and 12 months after surgery were set in a panel

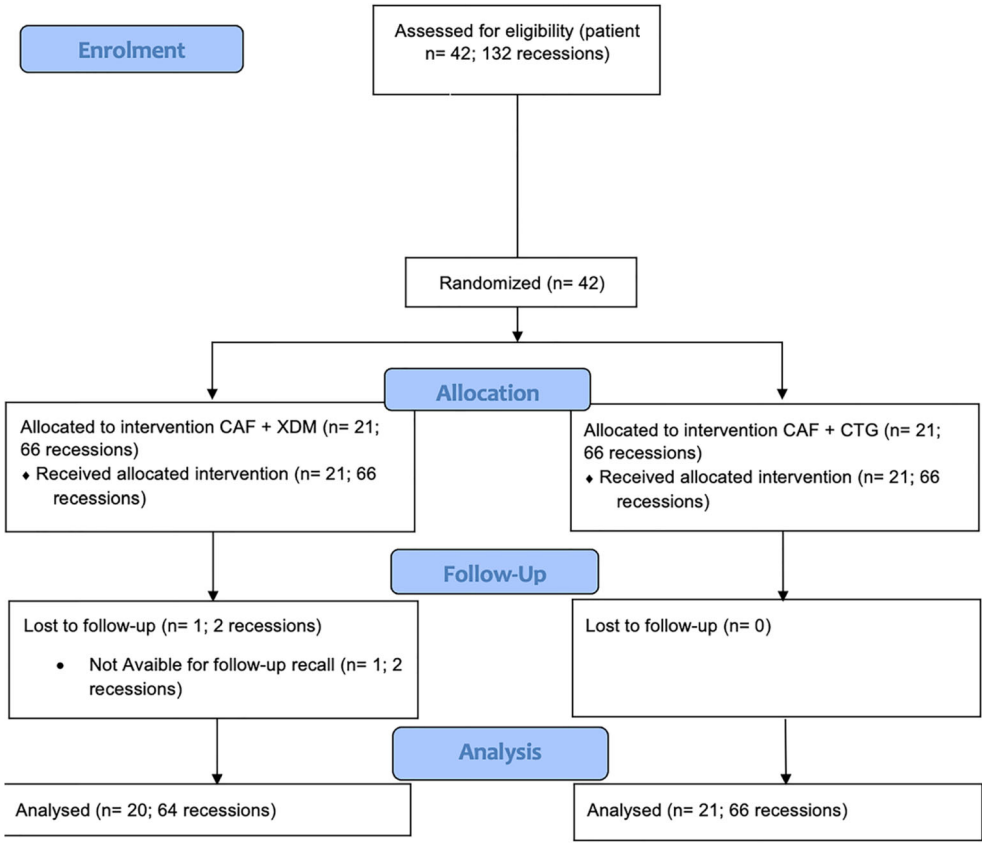

Fig. 3 Consort flow chart of the study

and evaluated by two different masked and calibrated (k >0.8) examiners.

Patient-reported outcomes

Questionnaires

The dentin hypersensitivity (DH) and the esthetic results were assessed by a Visual Analog Scale (VAS) from 0 to 10 at baseline and at 6 and 12 months after surgery. Root sensitivity was evaluated using an air spray approach [23]. Patient discomfort (post-operative pain) was also measured by VAS (from 0 to 10) at time intervals of 8 h, 24 h, 7 days, 14 days, and 30 days after the surgery.

Quality of life evaluation

Oral health-related quality of life was assessed by the OHIP-14 questionnaire at baseline, 6, and 12 months. OHIP-14 is used to evaluate seven subjective dimensions by means of 14 structured questions and responses on a 5-point Likert scale based on frequencies: never (0 points), hardly ever (1 point), occasionally (2 points), fairly often (3 points), and very often (4 points). Thus, the score of this questionnaire ranges from 0 to 56 points, with higher scores indicating a more negative impact of oral conditions on quality of life [24].

Table 1 Demographic characteristics and gingival recession location at baseline

	Groups		
	CAF + CTG	CAF + XDM	P-value
Characteristics			
Age (years)	38.1 ± 7.2	36.3 ± 6.1	p>0.05
Sex (male/female)	8/12	9/12	p>0.05
Teeth			
Central incisor	4	4	
Lateral incisor	6	6	
Canine	16	16	p<0.05
1st premolar	19	18	
2nd premolar	21	20	
Total	66	64	

CAF, coronally advanced flap; *CTG*, connective tissue graft; *XDM*, xenogeneic dermal matrix

There was no difference between groups for age (p>0.05; Student's *t* test)

There were no differences between groups for sex and location of the recession (p>0.05; Fisher exact test)

Table 2 Clinical parameters of the sites treated and RES at baseline, 6, and 12 months post-surgery

	Groups					
	CAF + CTG			CAF + XDM		
Time	Baseline	6 months	12 months	Baseline	6 months	12 months
Parameters						
GR	3.00 ± 0.78[a]	0.50 ± 0.78[b]	0.24 ± 0.58[b]	2.81 ± 0.77[a]	0.53 ± 0.63[b]	0.42 ± 0.68[b]
PD	1.74 ± 0.47	2.71 ± 0.60	2.22 ± 0.71	1.76 ± 0.55	2.73 ± 0.59	2.06 ± 0.73
CAL	4.56 ± 1.27[a]	2.68 ± 1.19[b]	2.89 ± 1.22[b]	4.14 ± 0.99[a]	2.72 ± 1.08[b]	2.65 ± 0.97[b]
RW	4.36 ± 1.42[a]	1.81 ± 2.27[b]	1.78 ± 2.20[b]	4.45 ± 1.53[a]	2.78 ± 2.34[b]	2.37 ± 2.30[b]
KTW	2.42 ± 1.29[a]	3.16 ± 1.22[b]	3.34 ± 1.11[b]	2.43 ± 1.12[a]	3.15 ± 1.00[b]	3.06 ± 0.92[b]
GT	0.85 ± 0.25[a]	1.70 ± 0.42[b]	1.53 ± 0.38[b]	0.81 ± 0.23[a]	1.39 ± 0.27[b]	1.26 ± 0.22*[b]
DH	5.60 ± 2.80[a]	1.25 ± 1.63[b]	0.75 ± 1.13[b]	5.84 ± 3.05[a]	1.64 ± 1.84[b]	0.98 ± 1.74[b]
m RC (%)		83.46 ± 18.9	91.79 ± 10.1		79.46 ± 18.7	80.19 ± 16.3
CRC (%)		78.7 (52)	83.3 (55)		62.5 (40)	70.3 (45)*
RES		8.10 ± 1.21	8.31 ± 1.02		7.92 0 ± 0.91	8.12 0 ± 1.03

CAF, coronally advanced flap; *CTG*, connective tissue graft; *XDM*, xenogeneic dermal matrix; *GR*, gingival recession height; *PD*, probing depth; *CAL*, clinic attachment level; *RW*, gingival recession width; *KTW*, keratinized tissue width; *GT*, gingival thickness; *DH*, dentine hypersensitivity; *mRC*, mean percentage of root coverage; *CRC*, complete root coverage; *RES*, Root-Coverage Esthetic Score

*Significant differences between groups at 12 months ($p<0.05$; Student's *t* test)

Different letters indicate significant differences between time point within the same group ($p<0.0$; repeated measures ANOVA and Tukey tests)

Statistical analysis

Statistical analysis was performed using JMP 13.0 SAS Institute Inc. Descriptive statistics were for summarizing data by using mean ± SD for quantitative variables and frequency and percentage for qualitative variables. The primary outcome variable was mean root coverage. Secondary variables included a percentage of teeth achieving CRC, 1.GR, RW, PD, CAL, KTW, GT, BOP, PI, surgery duration, RES, and patient-related outcomes. The significance of differences for quantitative variables among experimental times within each group was compared by repeated measures ANOVA, followed by post hoc analyses using the Tukey test. The significance of differences between groups within each experimental time was assessed by Student's *t* test. The significance of differences for categorical variables was compared by the Fisher exact test. The confidence interval considered was 95% for all analyses.

Table 3 Changes in clinical parameters from baseline to 12 months post-surgeries

	Groups		
	CAF + CTG	CAF + XDM	P-value
Parameters			
GR Red	2.75 ± 0.11	2.39 ± 0.12	0.03
RW Red	2.58 ± 1.22	2.08 ± 0.98	0.45
KTW Gain	0.99 ± 1.23	0.63 ± 0.83	0.06
GT Gain	0.77 ± 0.05	0.54 ± 0.03	0.01
mRC (%)	91.79 ± 10.1	80.19 ± 16.3	0.06
CRC (%)	83.3 (55)	70.3 (45)	0.01

CAF, coronally advanced flap; *CTG*, connective tissue graft; *XDM*, xenogeneic dermal matrix; *GR Red*, gingival recession height reduction; *RW Red*, recession width reduction; *KTW*, keratinized tissue width gain; *GT Gain*, gingival thickness gain; *mRC*, mean percentage of root coverage; *CRC*, complete root coverage

P-value <0.05 indicates significant differences between groups (Student's t-test or Fisher exact test)

Results

Subject retention, adverse effects, and compliance

The study was conducted between December 2017 and March 2020. Figure 3 presents the flow diagram of the study design. In total, 2400 subjects were assessed for eligibility and 42 entered the study (test group, n=21 subjects; control group, n=21 subjects). One subject from the test group did not return for the last follow-up visit. Thus, 20 and 21 subjects of groups CAF+XDM and CAF+CTG, respectively, completed the study for up to 12 months. A total of 130 gingival recessions were treated, 64 in group CAF+XDM and 66 in group CAF+

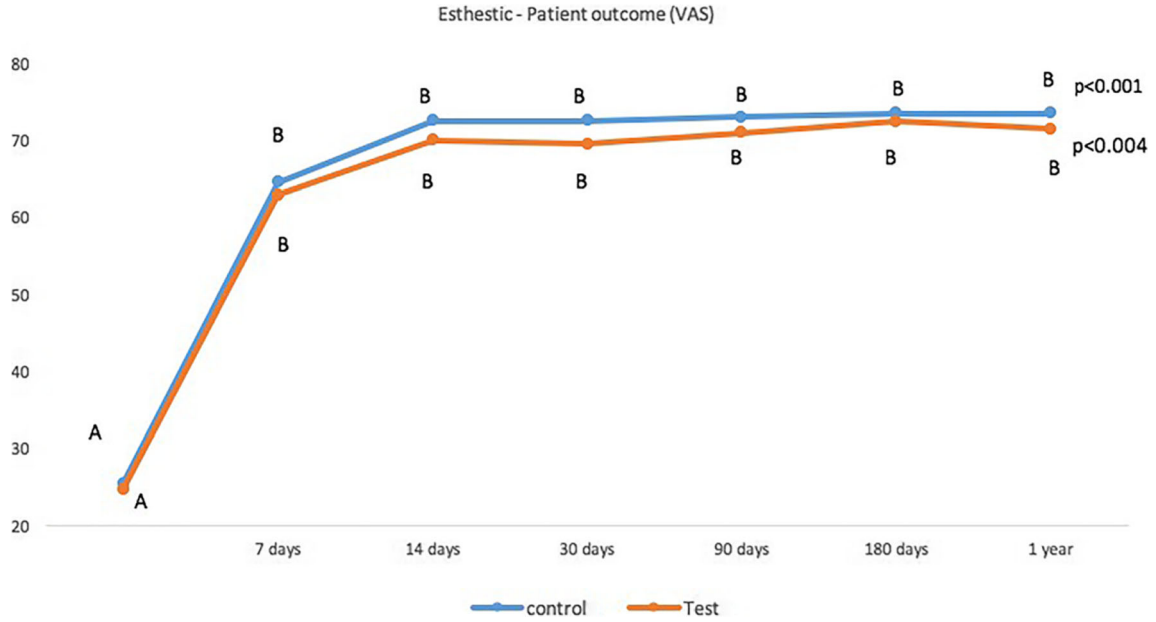

Fig. 4 Average patient esthetic score

CTG. No major adverse events were reported, and no lack of compliance was detected. The mean duration of the CAF + XDM procedure was 36 ± 8.1 min while the mean duration of the CAF + CTG surgery was 48.8 ± 15.06 min.

Clinical findings and esthetic evaluation

Groups CAF+XDM and CAF+CTG did not differ in terms of gender, sex, and group of the teeth with GR (p>0.05). Canines and premolars were the main teeth treated in both groups (Table 1). Full-mouth PI and full-mouth gingival bleeding were maintained ≤20% (data not shown) during the course of the study. Study sites showed no visible plaque and BOP during the study.

Clinical parameters and RES are presented in Table 2. Baseline mean GR was 3.00 ± 0.78 and 2.81 ± 0.77 mm for groups CAF+CTG and CAF+XDM, respectively. GR, CAL, RW, KT, GT, and DH showed significant improvement at 6 and 12 months when compared with baseline for the two groups ($p < 0.001$). At 12 months post-surgeries, the mRC values were 91.79% and 80.19% for groups CAF+CTG and CAF+XDM, respectively (p>0.05). Professional evaluation at 6 and 12 months post-operatively using the RES scale indicated no significant difference between groups (p>0.05). The frequency of teeth exhibiting CRC was significantly higher in the control than in the test group at 12 months (p<0.05); CRC was achieved in 83.3% (55 teeth) at 12 months in the control group against 70.3% (45) in the test group (Table 2). In

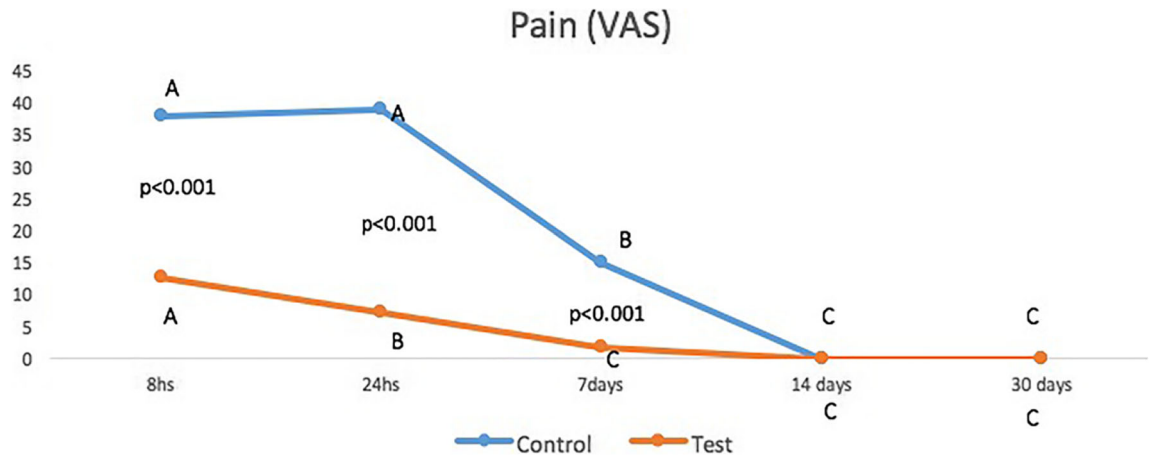

Fig. 5 Average post-operative pain values

addition, the mean GT at 12 months was significantly lower in the test group than in the control group (1.26 ± 0.22 and 1.53 ± 0.38, respectively) ($p<0.01$) (Table 2). No significant differences were observed between treatment groups for the other parameters described in Table 2 at baseline and at 6 and 12 months post-surgeries ($p>0.05$).

Table 3 presents the mean changes in clinical parameters from baseline to 12 months post-surgery. Mean reduction in recession was significantly lower in group CAF+XDM (2.39 ± 0.12, than in group CAF+CTG (2.75 ± 0.11) ($p=0.03$). In addition, the mean GT gain was significantly lower in the test group than in the control group (0.54 ± 0.03 and 0.77 ± 0.05, respectively) ($p=0.01$). No differences between groups were observed in RW reduction, KTW gain, and mRC reduction at 12 months ($p>0.05$).

Patient-reported outcomes

The results of patient esthetic satisfaction demonstrated a significant improvement in both groups at 12 months ($p<0.05$), without significant differences between groups ($p>0.05$) (Fig. 4). With regard to pain experience, the patients in group CAF+XDM reported having experienced significantly less pain until 7 days, when compared with group CAF+CTG ($p<0.05$) (Fig. 5). Both treatments showed a significant improvement in quality of life without significant difference between groups at 12 months (Fig. 6).

Discussion

In this study, the efficacy of CAF associated with XDM or CTG was compared in the treatment of MAGRs on non-molar maxillary teeth, in a period of up to 12 months of follow-up. The primary outcome was the mean root coverage at 12 months post-surgery. Overall results demonstrated that both surgical approaches yielded improvements in clinical parameters and these outcomes remained stable over time in both groups at 6 and 12 months, when compared with those at baseline. However, the group treated with CTG showed more favorable results in terms of reduction in GR, GT gain, and frequency of CRC achieved in teeth. Therefore, these findings indicated that CAF associated with XDM could provide improvements in the treatment of MAGRs on maxillary teeth. However, non-inferiority of XDM compared with CTG could not be established in terms of specific clinical parameters.

In this study, no differences were observed in mRC, GR, RW, and KTW measurements between the groups at 6 and 12 months of follow-up (Table 2). CAF + CTG showed higher mRC percentage compared with group CAF + XDM (91.79% vs 80.19% at 12 months), although not statistically significant (p-value of 0.06). While this finding is in line with the data literature and further confirms that CTG is the gold standard graft material for root coverage [2, 25], it should be noted that there was no statistically significant difference between the lower mRC value obtained with XDM was not statistically significant inferior than CTG.

To date, few RCTs have evaluated the effects of this specific porcine-derived collagen matrix (Mucoderm®) in the treatment of root recessions. However, there were variations between the surgical techniques, types, and locations of recessions among these studies [26, 27]. In support of our findings, a recent study compared the use of XDM with CTG, when associated with an extended CAF, in the treatment of single recessions [27]. The authors reported that both surgical approaches yielded significant proportions of root coverage, without difference between groups at 6 months (73.9% for CTG vs 61.3% for XDM), whereas Cieślik-Wegemund et al. [26], using a coronally advanced tunnel technique, reported significantly lower percentages of recession coverage in group XDM than in group CTG after 6 months of treatment of multiple recessions located in both maxilla and mandible (95% in group CTG vs. 91% in group XDM). Likewise, Pietruska et al. [28], also using a tunnel technique, showed lower mRC in group XDM (53.20%), when compared with group CTG (83.10%) for treatment of mandible recessions, after 12 months. These discrepancies among studies could be explained by differences in the efficacy of surgical techniques and in the predictability of recession coverage with regard to the type of recession (single/multiple, class) and location (maxilla/mandible) [29]. The mandible has less favorable anatomy for root coverage. Furthermore, it is more difficult to raise coronally advanced and stabilized flaps in the mandible due to the function of lip muscles and the smaller vestibule depth [30]. A recent multicenter re-analysis study showed that greater mean root coverage was achieved in maxillary teeth than in teeth in the mandible [31].

Noteworthy is that the percentages of teeth with CRC were significantly higher in group CAF+CTG (83%/55 recession) when compared with group CAF+XDM (70.3%/45 recession) (Table 3). In agreement with these results, previous RCTs have also reported inferiority of XDM when compared with CTG relative to this parameter [26, 28]. Moreover, two case series observed CRC in only 43% [32] and 40.7 % [33] of teeth at 12 months after treatment of multiple recessions with XDM associated with coronally advanced tunnel flaps. These results are all in line with a meta-analysis showing that CTG in conjunction with CAF achieved a significantly higher percentage of CRC and mean reduction in GR than CAF associated with xenogeneic collagen matrices in the treatment of GRs [34, 35].

Another important clinical finding of the present study was that gingival thickness (GT) gain at 12 months was significantly higher in Group CAF+CTG (0.77 mm on average) than in group CAF + XDM (0.54 mm on average). GT is an

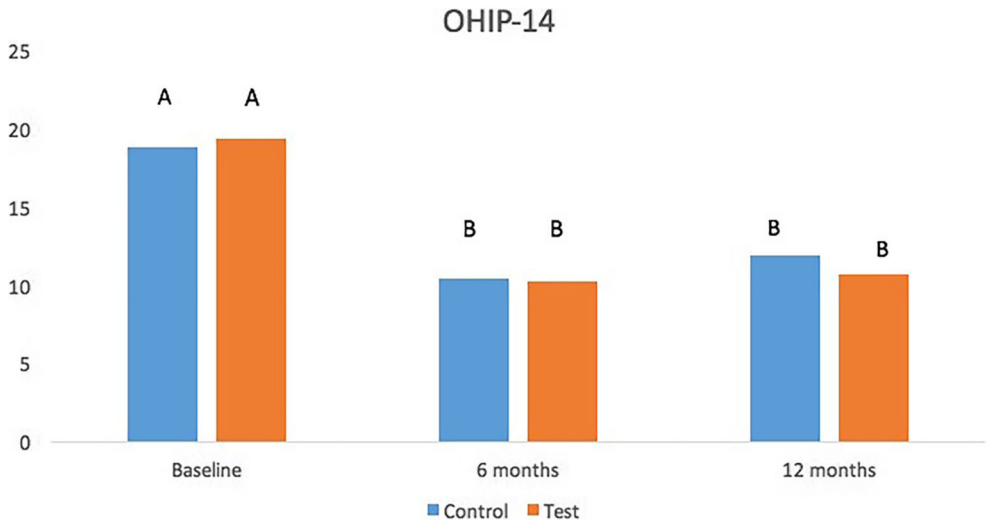

Fig. 6 Average of OHIP-14 scores

important component of the gingival phenotype, and according to a recent study by Barootchi et al. [36], it plays a key role in the stability of the gingival margin. Indeed, it was estimated that every 1 mm of GT gain obtained with root coverage procedures would lead to 0.71 mm less future recession over time [36].

In accordance with our results, Pietruska et al. [28] demonstrated a significantly higher gain in GT in sites treated with CTG than those treated with XDM at 12 months, whereas Suzuki et al. [27] observed no differences between CTG and XDM relative to GT gain at 6 months after surgeries. Another important point of discussion refers to the KTW, a component of the gingival phenotype that may also contribute to preventing future recurrence of recessions (secondary prevention) [37]. Notably, the mean increase of KTW obtained in the present study did not differ significantly between XDM (0.63 mm) and CTG (0.9 mm). This positive result in favor of the non-inferiority of XDM has also been demonstrated in other clinical studies [26, 27]. Therefore, even if to a lesser extent than the CTG, it seems that the xenogeneic collagen matrix used in the present study was able to modify the gingival phenotype, with the advantage of not needing a second surgical site and providing a shorter operative time.

The RES system has changed the paradigms of how the effectiveness of a recession treatment is assessed. Bearing in mind that 6 out 10 points of the RES system are based on the position of the gingival margin. Therefore, RES is especially sensitive to the relative performance of different surgical approaches and grafts/substitutes in terms of success or failure of root coverage [22]. In this study, test and control groups did not differ in terms of RES. This result might be partially attributed to the relatively small (and not statistically significant) difference in the mRC between groups CAF+XDM and CAF + CTG. Another possible explanation for this result could be that possible differences in soft tissue appearance after performing the two surgical approaches were too subtle to be perceived by professional examiners. This result is in agreement with previous RCTs that also found no difference in RES, when comparing xenogeneic collagen matrices and CTG associated with CAF [27, 38]. The overall equally high mean RES for test and control groups at 12 months post-surgeries (CAF+XDM: 8.12 versus CAF+CTG: 8.31) to some extent supported the benefits of XDM in terms of professional perception of root coverage and natural appearance of the soft tissues [39].

Patient-reported outcomes have been suggested to be important components of a successful treatment of gingival recessions. As clinicians, our aim should not be the final CRC outcome only, but also the patients' concerns about esthetics and morbidity. This study showed that from a patient's perspective, the two techniques allowed the reduction in DH and resulted in satisfactory esthetics and health-related quality of life. These data supported previous findings that root coverage was associated with improved patient satisfaction and sense of well-being [40, 41]. However, patients in group CAF+XDM experienced less post-operative pain/discomfort until 7 days, when compared with those in group CAF+CTG. This finding is in line with previous studies that showed that surgical approaches using CTG, but not using graft substitute, increased patient morbidity. Thus, among the advantages of using graft substitutes such as XDM, in comparison with the CTG, are the lower patient self-reported pain scores and shorter recovery times [12, 41].

One of the limitations of the present study was that it was conducted at a single center. In addition, overall shallow gingival recessions were included (mean baseline GR of 3 mm for control and 2.8 for test groups). Nevertheless, meticulous study design, appropriate sample size and statistical analysis, and use of a stent to increase the accuracy of the clinical measurements represent important strengths of this study. Lastly, it should be mentioned that the inclusion of only maxillary non-molar gingival recessions may represent the most

ideal condition for root coverage procedures and therefore future studies are needed to further explore the efficacy of XDM compared with CTG for mandibular and/or molar recession defects.

Conclusion

Both CAF+XDM and CAF+CTG yielded improvements in multiple maxillary gingival recession type I in terms of clinical and patient-centered outcomes over a period of 12 months. Both treatments showed similar mean root coverage. However, CAF+CTG was superior to CAF+XDM relative to the number of sites obtaining CRC and gaining gingival thickness. With regard to patient morbidity and surgical time, CAF+XDM outperformed CAF+CTG and therefore XDM may be considered a valid alternative to autogenous CTG for treating multiple maxillary gingival recessions.

Author contribution All the authors have made substantial contributions to the conception and design of the study. JMM was involved in data collection. MF and PMD were involved in data interpretation. JMM, JG, PMD, LT, GR, and MF were involved in drafting the manuscript. All the authors critically revised and approved the final version of the manuscript to be published.

Declarations

Ethical approval The study was conducted in compliance with the principles outlined in the experimentation involving human subjects in the Declaration of Helsinki of the World Medical Association (2013). The study protocol was reviewed and approved by the Research Ethics Committee of the School of Dentistry of the University of Guarulhos (protocol CAAE 74045317.7.0000.5506), and registered at *ensaiosclinicos.gov.br* (RBR-974c9j).

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare no competing interests.

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